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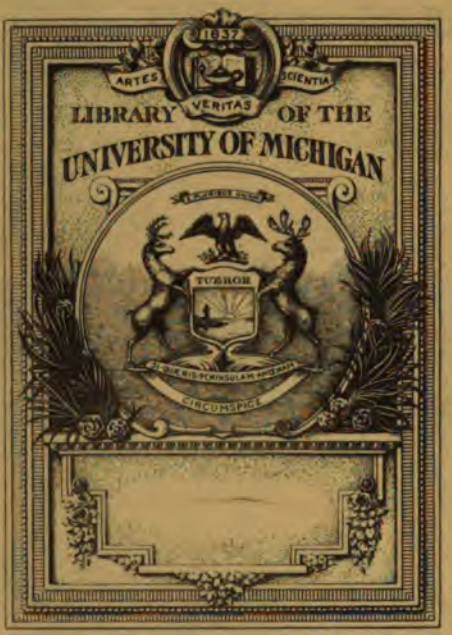

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TRAVELS IN THE AIR.

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Travels in the Air

BY

JAMES GLAISHER, F.R.S.,

CAMILLE FLAMMARION, W. DE FONVIELLE,

AND

GASTON TISSANDIER.

EDITED BY JAMES GLAISHER, F.R.S.

SECOND AND REVISED EDITION.

WITH ONE HUNDRED AND TWENTY-FIVE ILLUSTRATIONS.

LONDON:

RICHARD BENTLEY & SON, NEW BURLINGTON STREET,

Publishers in Ordinary to Her Majesty.

1871.

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LONDON:
R. CLAY, SONS, AND TAYLOR, PRINTERS,
BREAD STREET HILL.

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PREFACE TO THE SECOND EDITION.

A Second Edition enables me to speak concerning the use of the balloon during the siege of Paris.

When I laid down my pen a few months ago, I little thought that a new chapter was about to be added to the History of Aërostation, and that the time when the balloon would take its place as a necessary means of communication was so near at hand. Although, in common with my colleagues, I had long hoped to see more attention paid to the improvement of aërial navigation, still it is painful to reflect that the stimulus has been afforded by the misfortunes of France.

I had long felt satisfied that the balloon could be used with great advantage to explore the ocean overhead. As a philosophical instrument, although rude, costly, and most unmanageable, it had so many good points about it, that I was hopeful—as will be seen from the narratives in the body of the work—that its use would be attended with varied and important benefits to science. But an invention, however beautiful or interesting, unless it commends itself to some definitely expressed interest, or fulfils a purpose generally understood, is apt to languish. The balloon is a case in point. The necessity of exploring the aërial ocean, and seeking within its depths for the causes of atmospheric phenomena, has never yet been generally recognized. Situated at the lower confines of the atmosphere, we are limited in our observation of forces which, expended upon the earth, are conceived and regulated above. To trace the origin of these forces, to visit them in operation, to enter upon the boundless sea of inquiry they open, are sufficient reasons why physicists should

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regret the imperfection of the instrument, and the absence of combined efforts to improve it, but, it must be admitted, they afford no direct stimulus to quicken the apathy of the world at large.

When I say that Paris, under pressure of the siege, had recourse to the invention of her country, that for four months the balloon afforded the sole means of departure from the capital, and materially assisted in prolonging the resistance of the nation; and that, under the direction of the Post Office, it became the means of transmitting letters and despatches, and by it were conveyed from the city the pigeons by which alone it was possible for the provinces to communicate with the capital, I merely repeat what everybody knows; but the comprehensive scheme, organized by the Government, for the construction and management of balloons, and the regularity with which they were despatched, are not so well known. Further on will be found a list of the times of departure and places of descent of these air-ships, sent out in time of war to navigate an unknown ocean, to contend with darkness by night, and the enemy's fire by day.

Whatever may be the future of aërial navigation, the history of these first regularly sustained and hazardous ventures will never be without interest. Intimately connected with the siege, their record will ever remain to testify to the suffering and endurance of Paris.

For the following details, relating to the management and working of the Postal Service, and the manufacture of the balloons, I am indebted to the kindness of my colleagues, as well as to M. Jules Godard and M. de Simonin, the author of *La Vie souterraine, Les Pierres,* &c., who had himself ascended several times, and whose published account of aërostation during the siege, which recently appeared in the *Revue des Deux Mondes,* attracted general attention. Apart from the interest which must attach to all particulars illustrative of the state of Paris during the siege, these details have a special interest in their present place, as they carry on the course of enterprise pursued under happier auspices by MM. Flammarion, De Fonvielle, and Tissandier; the names of the last two gentlemen will appear once more in connection with new efforts.

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It should also be noticed that there is no break in the continuity of the voyages previously recorded with those belonging to the siege. The need was urgent, and there was no time to originate fresh constructions, or introduce new principles. The old invention as it stood was to be stimulated into success, if success were to be had. But it was necessary that new balloons should be made, and at once, for not a balloon in Paris at the commencement of the siege proved on examination to be sufficiently trustworthy to pass over the besieging lines in safety. To remedy at once this state of affairs extensive works were commenced. No pains were spared to avoid failure, and no detail was thought trifling enough to be overlooked.

The material was naturally the first consideration; this needed to be of even texture, without fault of manufacture, and above all strong. The fabric of greatest strength it is well known is that of silk, but silk was far too costly.

The material decided upon was calico, either white or coloured. That it should be gas-tight it was varnished with a mixture of linseed oil and oxide of lead. To make the oil consistent and dry the varnish was applied by a rag, and not by means of a brush, so that all the pores or chance apertures in the material were sealed and rendered thoroughly impervious to the escape of gas. This application was made to both sides when time permitted, but generally the outside alone was coated.

Two factories were established, one at the Orleans, and the other at the Northern Railway Station. The former was placed under the management of M. Godard; the latter under the direction of MM. Yon and Dartois. MM. Godard and Yon are known in London as having superintended and directed the ascents of M. Giffard's *Captive* balloon, at Ashburnham Park, Chelsea, in 1869. Both factories were under the direction of the Post Office.

The material employed at the Northern Station was white, that at the Orleans Station coloured, and both places adopted the same method of procedure in commencing. The size of each gore for the intended balloon was carefully drawn on a horizontal plan, just as is done in the construction of a globe. These gores were sewn together by hand at the Orleans Station, and by sewing machines at the

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Northern; each method had its advantages, the one affording greater speed, the other better work. After the sewing was completed, the balloons were varnished and filled with air for the purpose of searching out defects or flaws which might have been overlooked; while thus inflated the varnish dried most rapidly. The network, made of tarred flax, the car, and all the other appurtenances, were manufactured at these establishments.

Each of the two railway stations during this time of activity presented an extraordinary scene, the Orleans Station in particular. There women were engaged in the various branches of the work, drying and ironing, or carefully examining the materials to ensure their soundness. The calico was washed to destroy the acridity of the dye, and hung up to dry upon the woodwork of the station, ready to be cut up on the ground-plan. This operation, which required accuracy, was performed by numerous workwomen, under the personal direction of M. Godard; there might be seen every day nearly a hundred women, silent and attentive, marking with mathematical precision, by means of a pin and card, the distance between each point: this part of the work was shown to but few visitors. If time permitted, a second coating of varnish was applied: and this work, as well as all that followed, was performed by men, chiefly sailors.

It is stated that the sailors seemed to be quite at home with their work, painting, varnishing, weaving nets, twisting cables, and finally taking charge of the balloon on its journey.

The use of sewing machines rendered the activity at the Northern Station less remarkable, but these works also were full of interest. The endless pieces of calico hanging from wooden rails, the numerous work-people all busy with their needles, and the swollen shapes of the nearly completed balloons, are said to have afforded an extraordinary spectacle.

At the Northern Station the work-rooms were divided; but at the Orleans the enormous *Salle d'attente* was occupied, and the long row of coloured fabrics—yellow, blue, black, and green—suspended from the roof to dry, and occupying the midst of the immense nave, are described by visitors as being strongly suggestive of the interior of the Chapel of the Invalides.

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The balloons, which were constructed to contain about 70,000 cubic feet, were generally inflated with ordinary coal-gas. The bags of letters and despatches were firmly fixed outside the car. Higher up was secured a cage containing carrier-pigeons, intended to bring back news and replies to the outgoing letters.

I have endeavoured to learn some particulars about the pigeons employed, but, owing to the disturbed state of Paris, I have obtained but little information beyond that which has appeared in the newspapers. R. W. Alldridge, Esq., of Charlton, however, informs me that the pigeons used for the postal service during the siege were birds of a composite race and of no particular breed; their prominent characteristics were those of the Antwerp strain, the Antwerp itself being the produce of a variety of races of no intrinsic value.

In remarking that fancy pigeons may be produced of any colour or mark, and almost of any variety of feather, Mr. Alldridge assures me, from his own experience, that it is equally possible to regulate their intellectual development, and that these birds can be produced with different powers of orientation to meet the requirements of particular cases. The bird required to make journeys under 50 miles would materially differ in its pedigree from one capable of flying 500 or 600 miles. Attention in particular must be given to the colour of the eye: if wanted for broad daylight, the bird known as the "Pearl-eye," from its colour, should be selected, but if for foggy weather or for twilight flying, the black or blue-eye bird should receive the preference.

It can hardly, therefore, be matter of surprise that so many pigeons failed to return to Paris.

It was necessary to resort to special methods of preparing the return document which would have been otherwise too heavy and voluminous for their power of carriage. Photography was equal to the occasion, and long letters were reduced to within an area not exceeding one or two square inches on paper of the thinnest texture. These slips were sometimes rolled around the central feather of the bird's tail, being firmly secured about the shaft towards its base; at other times the despatches were wrapped around the legs of the bird; but generally they were enclosed inside a quill, and fastened to the central feather of the tail; the central feather is chosen, because it remains

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unmoved while its fellows radiate fan-like on either side during the bird's flight. On receiving these minute despatches they were submitted to the microscope, enlarged, copied, and forwarded to their destination.

Some of the pigeons returned on the day of departure, some after two or three days, and others after long intervals. Several returned, injured by birds of prey; a few were wounded by shots, for the Germans were as anxious to prevent the pigeons returning to Paris, as they were to stop the balloons leaving it. A great many of the pigeons were never heard of. One bird which left Paris on the 12th of October from the Orleans Station, by the balloon *Washington*, did not return till the 5th of December. The balloon itself took a northerly direction, and crossed the Prussian outposts in the midst of a well-sustained fire. The projectiles reached them at 2,500 and 3,000 feet, and the travellers did not feel secure until they had gained a height of 3,500 feet. They met with the same reception at Chantilly, Senlis, Compiègne, and Noyon. The enemy's fire ceased at some distance from Ham. Towards half-past eleven the balloon descended at Carrières, near Cambrai, in the midst of a violent gale, and the passengers were much hurt. The tables on pages xvi. to xx., containing the statistics and particulars of the departures of all the balloons that left Paris during the siege, their size, &c., have been most kindly furnished me by M. Jules Godard.

After the 20th of January MM. Godard removed from the Orleans to the Eastern Railway Station, in consequence of the works at the latter place having been damaged by Prussian shells, and one of the balloons in course of construction injured. An examination of the tables will show that after November 21 the ascents were at night. This change was made with the view of avoiding the fire of the besiegers. It was not, however, foreseen that the air is much calmer by night than by day, and that consequently the balloon would make but little progress at night; unfortunately, too, it was a rule established in Paris that no light of any kind should be used in a balloon—not even a Davy lamp—for fear of an explosion. It was therefore impossible to read the barometer; and in addition to the perils of these nocturnal ascents, the voyagers had no idea of their rate of travelling or their

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distance from the earth. This arose from an error, for I had myself used a Davy lamp and read all my instruments by its means at night; and when M. de Fonvielle left England, after his escape from Paris, with the view of attempting to re-enter the city by means of a balloon, I gave him a lamp which I had taken up several times previously in my ascents, for the triple purpose of enabling him to read the barometer, to warm his hands, and to heat coffee, with the assurance of its perfect safety.

Dr. Janssen, charged with a scientific mission to Algeria by the Government and the Academy of Sciences, for the purpose of observing the total eclipse of the Sun on December 22, left Paris December 2, 1870, at six o'clock in the morning, in the balloon *Volta*, of which he took the management. He carried several dismounted telescopes, packed with special care in such a manner as to prevent any accidents in the descent.

The *Volta* rose at first to 3,600 feet by parting with ballast, and afterwards by the action of the sun it rose by degrees to 7,200 feet, from which height it descended on the completion of its voyage.

Dr. Janssen offers some remarks on the rise and height of his balloon, and writes that, exposed to the full action of the sun's rays, the balloon itself became heated; that this heat was in turn communicated to the gas inside, which readily absorbed the higher temperature as gas absorbs, Dr. Janssen remarks, *obscure* heat more readily than *luminous* heat. Under this action the gas became equalized in temperature, and warm throughout as a solid body, leading him to believe that at 3,600 feet the action of the sun is felt chiefly through the medium of the envelope or material of the balloon, which acts as a transformer of the solar force.

But it struck Dr. Janssen with surprise that at sunrise the balloon fell, and rose again when the sun was several degrees above the horizon.

He explains these effects by the same principle: the power of the sun on rising dissipated the mist, and increased the calmness of the sky, while the envelope of the balloon radiating heat into space became rapidly cooler, and was far from receiving as much heat from the rising sun as it parted with by radiation. The result showed

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itself in the cooling of the gas and consequent descent of the balloon. Later on, the balloon rose high in the heavens, the gain was greater than the loss, and the balloon continued to rise unchecked so long as the temperature of the gas increased.

The *Volta* passed above Chartres, Le Mans, and Château-Gontier. The weather was very fine. Dr. Janssen marked the route by means of a compass placed for this purpose. His descriptions of an instrument for determining the speed and route of a balloon appear in *Les Comptes Rendus de l'Académie des Sciences de Paris*, 27th February and 13th March.

During the journey he had occasion to make various scientific observations, in brief detail as follows:—

At 11h. 15m. the sea was visible, and M. Janssen commenced the descent, which took place without accident, although the wind on the ground was very strong.

This fortunate result he attributes to the employment of a guide-rope 980 feet in length, which moderated the fall and checked the dragging.

At the time of landing the *Volta* was at Briche-Blanc, arrondissement of St. Nazaire, at the mouth of the Loire.

The balloon had travelled nearly 300 miles in five hours and a quarter.

The instruments were found to be in perfect order, and the voyage proves that it is possible to carry in a balloon delicate astronomical instruments, if precautions are taken, as in this journey.

The siege of Paris gave a great impetus to all aërostatical inquiries; and many attempts were made during the siege, in different parts of the city, to steer balloons. The Western Railway Company lent some of their rooms to be used for such experiments, and a part of the manufactory at Cail was placed at the disposal of M. Vert, whose invention was shown at the exhibition of the Aëronautical Society at the Crystal Palace, a year or two since.

Of all these attempts, the most appreciated in Paris is that of M. Dupuy de Lôme, a shipbuilder, a practical man, and a mathematician. The Government granted to this gentleman a sum of

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£1,600, necessary to carry out his design, which is to make a balloon in the form of a fish, furnished in the back part with a sail like a helm, and with a screw for propulsion. Within the balloon the inventor proposes to place a spherical ball filled with air, similar to the swimming bladder of a fish, in order to avoid any waste of gas, and to assist in ascending and descending; it would also keep the balloon well filled. M. Dupuy de Lôme considers that his balloon will never struggle with the wind, but will move forward against the pressure of the air current with the speed of five miles an hour, and that six men, relieving one another, will be sufficient to turn the wheel which puts the screw in motion.

For inflating the balloon hydrogen gas will be employed, and silk is the material adopted for its outer casing. Great hopes have been entertained in Paris, and may be still, that this invention of M. Dupuy de Lôme may help to solve the problem of Aërial Navigation. I cannot affect to share in this expectation.

In England the subject of Aërostation has made but little progress, and no valuable invention has arisen to facilitate travelling in the air. In all my ascents I used the balloon as I found it. The desire which influenced me was to ascend to the higher regions and travel by its means in furtherance of a better knowledge of atmospheric phenomena; neither its management nor its improvement formed a part of my plan. I soon found that balloon travelling was at the mercy of the wind, and I saw no probability of any method of steering balloons being obtained. It even appeared to me that the balloon itself, admirable for vertical ascents, was not necessarily a first step in Aërial Navigation, and might possibly have no share in the solution of the problem. It was this conviction that led to the formation of the Aëronautical Society a few years since, under the presidency of the Duke of Argyll. In the number of communications made to this Society, it is evident that many minds are taxing their ingenuity to discover a mode of navigating the air; all kinds of imaginary projects have been suggested, some showing great mechanical ingenuity, but all indicating the want of more knowledge of the atmosphere itself. The first great aim of the Society is the

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connecting the velocity of the air with its pressure on plane surfaces at various inclinations.

There seems no prospect of obtaining this relation otherwise than by a careful series of experiments. But little can be expected from the mathematical theory; it is a hundred and forty years since the general differential equations of fluid motion were given to the world by D'Alembert; but although many of the greatest mathematicians have attempted to deduce from them results of practical value, it cannot be said that any great success has attended their efforts. The progress made has been very slight in the case of water, where the analysis is much simpler than for an elastic fluid like air; and the Theory of Resistances, which is the part of Hydromechanics which has the most direct bearing on Aërial Navigation, is perhaps the part of the subject about which least is known.

A good deal of attention has been paid to one subject, namely, the resistance of the air to the motion of projectiles, and numerous experiments, from the time of Halley to our own day, have been made on this subject.

It needs but a slight acquaintance with these researches to appreciate the difficulties of the investigation, which, on account of the comparatively small size of the projectile and the great rapidity of its motion, presents some features which render the inquiry somewhat more simple than the general investigation on which the foundation of the science of Aërial Navigation must rest.

The Aëronautical Society have been endeavouring for some time to organize a systematic series of experiments on the connection between the pressure and velocity of air, and it is believed that these will afford the only data on which a true science of Aëronautics can be founded.

Even if the experiments should not advance Aëronautics as much as there is every reason to expect, at all events they will yield results not only of very high scientific interest, but also of practical value.

The siege of Paris is now a thing of the past, as are also the balloon pigeon-posts; but the balloon has proved itself so great an assistance to the French nation, that it will command attention and

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study which must be a source of great benefit to Aërial Navigation, and verify, in one instance at least, the well-known saying, which however is very far from being universally true, that Progress and Invention spring from the exigencies of war.

JAMES GLAISHER.

March 1871.

JAMES GLAISHER, F.R.S.

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LISTS OF THE BALLOONS WHICH LEFT PARIS DURING THE SIEGE.

NO.	DAY OF DEPARTURE. 1870.	NAMES OF THE BALLOONS AND THEIR CUBICAL CONTENTS.	NAMES OF THE AERONAUTS AND PASSENGERS.	PLACE AND HOUR OF DEPARTURE.	PLACE OF DESCENT.	GENERAL REMARKS.
1	September 23rd.	Le Neptune. 52,800 cubic feet.	Duruof, alone.	Place St. Pierre (Montmartre), 8h. 30m. A.M.	Evreux.	227 lbs. of letters.
2	September 25th.	La Cité de Florence. 66,880 cubic feet.	Mangin and Grand-Champ.	Boulevard d'Italie, 1h. P.M.	Vernouillet.	231 lbs. of letters and 6 pigeons.
3	September 29th.	Les Etats-Unis. 24,640 cubic feet. And a second balloon of 17,600 cubic feet.	Louis Godard and Courtin.	Usine de la Villette, 10h. A.M.	Mantes.	128 lbs. of despatches and pigeons.
4	September 30th.	Le Céleste. 26,048 cubic feet.	Tissandier, alone.	Usine de Vaugirard, 10h. A.M.	Dreux, Normandy.	176 lbs. of despatches and pigeons.
5	September 30th.	A double-paper balloon. 4,541 cubic feet.	.....	Boulevard d'Italie, 1h. A.M.	.....	59 lbs. of despatches and proclamations.
6	October 7th.	L'Armand Barbès. 52,800 cubic feet.	Trichet, cousin of M. Godard, accompanied by Gambetta and his secretary.	Place St. Pierre (Montmartre), 11h. 15m. A.M.	Epineuse, 3.30 A.M.	22 lbs. of despatches and pigeons.
7	October 7th.	Le Georges-Sand.	Three passengers.	Place St. Pierre (Montmartre).	.....	Without despatches.
8	October 12th.	Le Washington. 72,125 cubic feet.	Bertaux, accompanied by Lefébvre, a proprietor of pigeons, and Vonroosbeck.	Orleans Railway Station, 8h. A.M.	Carnières, Nord.	660 lbs. despatches and pigeons.
9	October 12th.	Le Louis Blanc. 70,400 cubic feet.	Farcot, and Traclet, a proprietor of pigeons.	Place St. Pierre (Montmartre), 9h. A.M.	Belgium.	275 lbs. of despatches and pigeons.
10	October 14th.	Le Godefroy Cavagnac. 72,125 cubic feet.	M. Godard, sen., accompanied by Kératry and his two secretaries.	Orleans Railway Station, 10h. A.M.	Near Bar-le-Duc, Brillon.	374 lbs. of despatches and pigeons.
11	October 14th.	Le Christophe Colomb. 72,125 cubic feet.	Tissandier, accompanied by Ranc and Féron.	Orleans Railway Station, 1h. 15m. A.M.	Nogent, on the Seine.	594 lbs. of despatches and pigeons.
12	October 16th.	Le Jules Favre. 72,125 cubic feet.	Louis Godard, jun., accompanied by Malapert, Ribot, and Beoté.	Orleans Railway Station, 7h. 15m. A.M.	Belgium.	429 lbs. of despatches and pigeons.
13	October 16th.	Le Jean Bart. 72,125 cubic feet.	Labadier, quartermaster from Fort Montrouge, accompanied by Barthélémy and Dary.	Orleans Railway Station, 10h. A.M.	Belgium.	594 lbs. of despatches and pigeons.
14	October 18th.	Le Victor Hugo. 70,400 cubic feet.	Nadal, alone.	Garden of the Tuileries, Noon.	Belgium.	968 lbs. of despatches and pigeons.

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15	October 17th.	La Liberté (constructed by Jules Godard, and used by him for captive ascents at the Exhibition of 1867). 176,000 cubic feet.	M. Fonvielle intended to ascend in this balloon.	Usine de la Villette.	Near Le Bourget (in the Prussian lines).	This balloon broke away during the inflation.
16	October 19th.	Le Lafayette. 72,125 cubic feet.	Jossec, a seaman from the fort of Bicêtre, accompanied by M. Dubost and his secretary.	Orleans Railway Station, 9h. A.M.	.....	671 lbs. of despatches and pigeons.
17	October 22nd.	Le Garibaldi. 70,400 cubic feet.	Iglésia and Jouvencel.	Garden of the Tuileries, 11h. 15m. A.M.	Meaux.	990 lbs. of despatches and pigeons. Descended at Meaux, occupied by the Prussians. The despatches and materials saved in a dung-cart.
18	October 25th.	Le Montgolfier. 71,984 cubic feet.	Herré, a seaman from the fort of Bicêtre, accompanied by Colonel Lapierre and Commander Legouedec.	Orleans Railway Station, 8h. A.M.	.....	638 lbs. of despatches and pigeons.
19	October 27th.	Le Vauban. 71,984 cubic feet.	Guillaume, a seaman from the fort of Bicêtre, accompanied by M. Leitlinger, in the service of the Government, and by Cassier, a proprietor of pigeons.	Orleans Railway Station, 8h. 45m. A.M.	Between Metz and the frontier.	594 lbs. of despatches and pigeons. Descended between Metz and the frontier. Aëronaut and despatches saved.
20	October 29th.	Le Colonel Charras. 70,400 cubic feet.	Gilles, alone.	Northern Railway Station.	Belgium.	1012 lbs. of despatches and pigeons.
21	November 2nd.	Le Fulton. 72,125 cubic feet.	Leglorennec, a seaman from the fort of Bicêtre, and Ozanne, an engineer.	Orleans Railway Station, 8h. 45m. A.M.	.....	550 lbs. of despatches and pigeons.
22	November 4th.	Le Ferdinand-flocon. 70,400 cubic feet.	Vidal and Lemercier de Janval.	Northern Railway Station, 9h. A.M.	.....	286 lbs. of despatches and pigeons.
23	November 4th.	Le Galilée. 71,984 cubic feet.	Husson, a sailor, and Etienne Antonin, an engineer.	Orleans Railway Station, 2h. 18m. P.M.	Near Orleans.	924 lbs. of despatches and pigeons. Descended near Orleans, on the day when that town was re-occupied by the Prussians. The aëronaut and engineer made prisoners and sent to Germany, from whence Antonin succeeded in escaping and returned to Tours.
24	November 6th.	La Ville de Châteaudun. 70,400 cubic feet.	Bocs, alone.	Northern Railway Station, 9h. 45m. A.M.	Roclainville (Eure et Loir).	979 lbs. of despatches and pigeons.
25	November 8th.	La Gironde. 71,984 cubic feet.	Galley, a sailor, accompanied by MM. Herbault, Gambés, and Barry. (The balloon freighted by them.)	Orleans Railway Station, 8h. 30m. A.M.	Gondreville, near Bordeaux.	132 lbs. of despatches and pigeons. The travellers left Paris to try and reach Bordeaux, and descended at Gondreville, near Bordeaux.
26	November 12th.	Le Daguerre. 71,984 cubic feet.	Jubert, a sailor, accompanied by Mobécourt, a proprietor of pigeons, and Pierson, an engineer.	Orleans Railway Station, 9h. 15m. A.M.	Ferrières.	572 lbs. of despatches and pigeons. Descended at Ferrières, occupied by the Prussians. Made prisoners. The despatches were saved by a forester; and, thanks to this brave citizen, were sent by Buffet, the aëronaut of the *Archimède*, who had gone in search of them across the Prussian lines, for which he was decorated by General Trochu. Pierson succeeded in escaping.

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NO.	DAY OF DEPARTURE. 1870.	NAMES OF THE BALLOONS AND THEIR CUBICAL CONTENTS.	NAMES OF THE AERONAUTS AND PASSENGERS.	PLACE AND HOUR OF DEPARTURE.	PLACE OF DESCENT.	GENERAL REMARKS.
27	November 12th.	Le Niépce. 71,984 cubic feet.	Pagano, a seaman from the fort of Romainville, accompanied by Herbault, Dagron, Fernic, Poisot, and Guocchi.	Orleans Railway Station, 9h. 16m. A.M.	Châlons-sur-Marne.	Supplied with microscopic photographic apparatus. Descended at Châlons-sur-Marne, not far from the enemy. A part of the apparatus, which was with great difficulty saved, remained there for eight days.
28	November 18th.	Le Général Uhrich. 70,400 cubic feet.	Bienbao, accompanied by Chapouil and a proprietor of pigeons.	Northern Railway Station, 11h. 15m. A.M.	Luzarches (Seine et Oise).	176 lbs. of despatches and pigeons.
29	November 21st.*	L'Archimède. 71,984 cubic feet.	Buffet, a seaman, from the fort of Bicêtre, accompanied by St. Valery and Jaudas.	Orleans Railway Station, 1h. A.M.	Castelzé (Holland). 7h. A.M.	484 lbs. of despatches and pigeons. Buffet is the seaman who went in search of the despatches of the balloon *La Daguerre*, at Ferrières.
30	November 24th.	La Ville d'Orléans. 70,400 cubic feet.	Rollier and Deschamps.	Northern Railway Station, 11h. 30m. P.M.	In Norway, 600 miles north of Christiania.	550 lbs. of despatches and 6 pigeons.
31	November 25th.	L'Égalité.	Fonvielle and passengers.	.....	Belgium.	
32	November 28th.	Le Jacquard. 70,400 cubic feet.	Prince, a seaman, from the fort of Montrouge, alone.	Orleans Railway Station, 11h. 15m. P.M.	Unknown.	550 lbs. of despatches and pigeons. Was seen above Rochelle. A bag of despatches from this balloon was picked up in the Channel.
33	November 30th.	Le Jules Favre (second of that name). 70,400 cubic feet.	Martin and Ducauroy.	Northern Railway Station, 11h. P.M.	Unknown.	110 lbs. of despatches and pigeons. Seems to have shared the same fate as the *Jacquard*.
34	November 30th.	La Bataille de Paris. 70,400 cubic feet.	M. Lissajous and two passengers.	.....	Near the Mouth of the Loire.	
35	December 2nd.	Le Volta. 71,984 cubic feet.	M. Janssen, the astronomer, accompanied by Chapelain, a seaman.	Orleans Railway Station, 5h. A.M.	St. Nazaire.	Without despatches. This balloon was given to M. Janssen by the Minister of Public Instruction, to enable him to observe the eclipse of the sun on December 22.
36	December 5th.	Le Franklin. 71,984 cubic feet.	Marciat, a seaman from the fort of Montrouge, and an officer of the rank of major-general.	Orleans Railway Station, 5h. A.M.	.....	220 lbs. of despatches and 6 pigeons.
37	December 5th.	Le Denis-Papin. 71,984 cubic feet.	Demalin, a seaman from the fort of Ivry, accompanied by MM. Delort, Robert, and Montgaillard.	Orleans Railway Station, 5h. A.M.	Chatenay, near Nantes.	121 lbs. of despatches and 6 pigeons.
38	December 11th.	Le Géneral Renault. 70,400 cubic feet.	Wolff and Larmanjat.	Northern Railway Station, 2h. 15m. A.M.	.....	143 lbs. of despatches and 12 pigeons.

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39	December 15th.	La Ville de Paris. 70,400 cubic feet.	Delamarne, accompanied by MM. Morel and Billebault.	Northern Railway Station, 4h. A.M.	Solingen, Duchy of Nassau.	143lbs. of despatches. Made prisoners; Delamarne succeeded in escaping, and returned to Paris.
40	December 17th.	Le Parmentier. 71,984 cubic feet.	Paul, a seaman from the fort of Rosny, MM. Jules, sen., a franc-tireur, and Dedouet, employed in the microscopic photography.	Orleans Railway Station, 1h. 20m. A.M.	Gourgançon (Marne).	264 lbs. of despatches and pigeons.
41	December 17th.	Le Gutenberg. 71,984 cubic feet.	Perruchon, a seaman from the fort of Rosny, and MM. Louisy, Lévy, and D'Alméida.	Orleans Railway Station, 1h. 20m. A.M.	Ligny.	330 lbs. of despatches and pigeons. Descended at Ligny, occupied by the Prussians. The despatches and passengers were saved.
42	December 18th.	Le Davy. 70,400 cubic feet.	Chaumont, a seaman from the fort of Rosny, and M. Deschamp, sent on postal service.	Orleans Railway Station, 5h. A.M.	Roche-sur-Yonne.	55 lbs. of despatches and pigeons.
43	December 20th.	Le Général Chanzy. 70,400 cubic feet.	Farriche, and MM. de Lépinay, Julliac, and Joufryou.	Northern Railway Station, 2h. 30m. A.M.	Munich.	55 lbs. of despatches and pigeons. They were all made prisoners at Munich.
44	December 22nd.	Le Lavoisier. 71,984 cubic feet.	Sauveur Ledret, a seaman from the fort of Ivry, and M. Boisdeffre.	Orleans Railway Station, 2h. A.M.	Beaufort en Vallée (Maine et Loir).	385 lbs. of despatches and pigeons.
45	December 23rd.	La Délivrance. 70,400 cubic feet.	Cauchet and Reboul, charged with a mission.	Northern Railway Station, 3h. 30m. A.M.	.....	242 lbs. of despatches and 4 pigeons.
46	December 24th.	Le Rouget de l'Isle. 71,984 cubic feet.	Jahu, a seaman from the fort of Montrouge, MM. Garnier, proprietor of the balloon, Clachant, Tarbé des Sablons, and Grisal.	Orleans Railway Station, 8h. A.M.	La Ferténacé (Orne)	242 lbs. of despatches and pigeons.
47	December 27th.	Le Tourville. 71,984 cubic feet.	Moutet, a seaman from the fort of Noisy, MM. Niège, Delalue, and Simon.	Orleans Railway Station, 3h. 45m. A.M.	Emoutiers (Haute Vienne), 1h. P.M.	352 lbs. of despatches and pigeons.
48	December 29th.	Le Bayard. 71,984 cubic feet.	Reginensi, a seaman from the fort of Montrouge, and M. Ducoux, director of the Cab Company.	Orleans Railway Station, 4h. A.M.	Napoléon Vendée, 10h. A.M.	242 lbs. of despatches and pigeons.
49	December 31st.	L'Armée de la Loire. 70,400 cubic feet.	Lemoine, alone.	Northern Railway Station, 5h. A.M.	.....	550 lbs. of despatches and pigeons.
	1871.					
50	January 4th.	Le Newton. 71,984 cubic feet.	Ours, a seaman, 2nd Master of the fort of Montrouge, and M. Brousseau.	Orleans Railway Station, 4h. A.M.	Mortagne (Orne).	209 lbs. of despatches. 471 lbs. of freight. Descended at Mortagne, near the enemy; but the aëronaut and passengers were saved.
51	January 9th.	Le Duquesne. 71,984 cubic feet.	Richard, a seaman from the fort of Romainville, MM. Chemin, Lallemagne, and Aymond, seamen.	Orleans Railway Station, 8h. A.M.	.....	220 lbs. of despatches and 4 pigeons. This aerostat was furnished with the helicoidal apparatus; the system of Admiral Labrousse.
52	January 10th.	Le Gambetta. 70,400 cubic feet.	Duvivier and the engineer, Lefébvre de Fourcy.	Northern Railway Station, 3h. A.M.	.....	48 lbs. of despatches, 3 pigeons, and 480 lbs. of freight.
53	January 11th.	Le Képler. 71,984 cubic feet.	Roux, a seaman from the fort of Rosny, and M. Dupuis.	Orleans Railway Station, 3h. 30m. A.M.	.. ...	55 lbs. of despatches and pigeons, and 297 lbs. of freight.

It was decided that after this date the ascents should be made at night.

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NO.	DAY OF DEPARTURE. 1871.	NAMES OF THE BALLOONS AND THEIR CUBICAL CONTENTS.	NAMES OF THE AËRONAUTS AND PASSENGERS.	PLACE AND HOUR OF DEPARTURE.	PLACE OF DESCENT.	GENERAL REMARKS.
54	January 13th.	Le Monge. 71,984 cubic feet.	Raoul, a seaman from the fort of Bicêtre, and M. Guignier, proprietor of the balloon, and one of his friends.	Orleans Railway Station, 8h. A.M.	.....	Despatches and pigeons.
55	January 13th.	Le Général Faidherbe. 70,400 cubic feet.	Van, Seymortier, and Hurel.	Northern Railway Station, 8h. A.M.	.....	132 lbs. of despatches, 3 pigeons, 4 sheep-dogs, intended to cross the Prussian lines, and return to Paris with despatches concealed in their collars.
56	January 15th.	Le Vaucanson. 71,984 cubic feet.	Clariot, a seaman from the fort of Montrouge, and MM. Valade and Delante.	Orleans Railway Station, 3h. A.M.	.....	165 lbs. of despatches and 3 pigeons.
57	January 18th.	La Poste de Paris. 70,400 cubic feet.	Turbiaux, Clairet, and Cavailhou.	Northern Railway Station, 3h. 30m. A.M.	.....	154 lbs. of despatches and 3 pigeons.
58	January 20th.	Le Général Bourbaki. 70,400 cubic feet.	Mangin, jun., and Boisanfrey.	Northern Railway Station, 5h. 15m. A.M.	.....	275 lbs. of despatches and 4 pigeons.
59	January 22nd.	Le Général Daumesnil. 71,984 cubic feet.	Robin, a seaman from the fort of Bicêtre, alone.	Eastern Railway Station, 3h. 15m. A.M.	.....	616 lbs. of despatches and 3 pigeons.
60	January 24th.	Le Torricelli. 71,984 cubic feet.	Bely, a seaman from the fort of Ivry, alone.	Eastern Railway Station, 3h. A.M.	.....	506 lbs. of despatches and 3 pigeons. Descended in L'Oise in the midst of the Prussian lines. The despatches were saved, and sent to the Post Office at Blangy and Abbeville.
61	January 27th.	Le Richard Wallace. 70,400 cubic feet.	Emile Lacaze, alone	Northern Railway Station, 2h. 30m. A.M.	.....	506 lbs. of despatches and 2 pigeons. It is believed this balloon fell into the sea, as it was seen to hover for some time over Bassin d'Arcachon.
62	January 28th.	Le Cambrone.	Tritan, a sailor from the fort of Ivry, alone.	Eastern Railway Station, 5h. A.M.	.....	44 lbs. of despatches and pigeons. This balloon is the last that was sent out; and carried despatches, ordering the ships to proceed to Dieppe for the revictualling of Paris. Descended in the département de la Sarthe.

At the conclusion of the siege, the Réaumur, the Monthyon, the Nelson, the Guillaume Tell, and the Union des Peuples, were ready for sailing.

The total number of balloons sent out by the Post Office during the siege was 54. They carried about 2,500,000 letters, representing a total weight of nearly 10 tons.

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CONTENTS.

PART I.

AËRIAL TRAVELS OF MR. GLAISHER.

PAGE

INTRODUCTION 1

CHAPTER I.

THE FIRST SCIENTIFIC ASCENTS IN ENGLAND 23

CHAPTER II.

MY FIRST ASCENT—WOLVERHAMPTON, JULY 17, 1862 33

CHAPTER III.

ASCENTS FROM WOLVERHAMPTON, AUG. 18 AND SEPT. 5, 1862 48

CHAPTER IV.

ASCENTS FROM THE CRYSTAL PALACE, APRIL 18 AND JULY 11, 1863. . . 59

CHAPTER V.

ASCENT FROM WOLVERTON, JUNE 26, 1863 64
ASCENT FROM THE CRYSTAL PALACE, JULY 21, 1863 72

CHAPTER VI.

ASCENT FROM WINDSOR, MAY 29, 1866 74

CHAPTER VII.

OVER LONDON BY DAY, MARCH 31, 1863 78
OVER LONDON BY NIGHT, OCTOBER 2, 1865 80

Digitized by Google

CHAPTER VIII.

PAGE

DECREASE OF TEMPERATURE WITH ELEVATION 84
ANEROID BAROMETER: BLACKENED BULB THERMOMETER 90
LINES IN THE SPECTRUM: TIMES OF VIBRATION OF A MAGNET 91
DIFFERENT DIRECTIONS OF THE WIND: VELOCITY OF THE WIND 92
PHYSIOLOGICAL OBSERVATIONS: PROPAGATION OF SOUND 94

CHAPTER IX.

THE HIGH REGIONS 94
APPEARANCE OF THE EARTH VIEWED FROM A BALLOON 99

PART II.

TRAVELS OF M. C. FLAMMARION.

PRELIMINARY CHAPTER.

A SKETCH OF SCIENTIFIC BALLOONING FROM 1783 TO 1867 105

CHAPTER II.

MY FIRST AËRIAL VOYAGE, ASCENSION DAY, 1867 122

CHAPTER III.

MY SECOND VOYAGE, 9TH JUNE, 1867—DESCRIPTION OF THE BALLOON—CONDITIONS OF SECURITY REQUIRED FOR AN AËRIAL VOYAGE 132

CHAPTER IV.

MORNING ASCENT—THE BLUE SKY—THE RESPIRABLE ATMOSPHERE . . . 143

CHAPTER V.

A VOYAGE IN TWO STAGES—EVENING: ST. CLOUD, VERSAILLES, DREUX. NIGHT: VERNEUIL, LAIGLE, DESCENT INTO THE RIVER ORNE 157

CHAPTER VI.

FROM PARIS TO LA ROCHEFOUCAULT-ANGOULEME—SIXTH VOYAGE 172

Digitized by Google

CHAPTER VII.

PAGE
ASCENT AT SUNSET 186

CHAPTER VIII.

FROM PARIS INTO PRUSSIA, BY ROCROI, AIX-LA-CHAPELLE, AND COLOGNE . 197

CHAPTER IX.

FROM PARIS INTO PRUSSIA *continued*; 206

CHAPTER X.

FROM THE CONSERVATOIRE DES ARTS ET MÉTIERS TO THE GARDENS OF BEAUGENCY 217

PART III.

TRAVELS OF MM. FONVIELLE AND TISSANDIER.

CHAPTER I.

THE LAST VOYAGES OF THE "GIANT" 233
(W. de Fonvielle.)

CHAPTER II.

THE CAPTIVE BALLOON AT THE EXHIBITION— THE FALLING STARS . . . 253
(W. de Fonvielle.)

CHAPTER III.

THE "ENTREPRENANT" BALLOON—VOYAGE FROM PARIS TO FERRIÈRES . . 267
SECOND ASCENT—FROM PARIS TO COMPIÈGNE 271
THIRD ASCENT—FROM PARIS TO COURCELLES (LOIRET) 282
(W. de Fonvielle.)

CHAPTER IV.

MY DÉBUT IN AËROSTATION—VOYAGE ABOVE THE NORTH SEA 290
(G. Tissandier.)

Digitized by Google

CHAPTER V.

PAGE
FORTUNE AND MISFORTUNE.—VOYAGE FROM THE CONSERVATOIRE 310
(W. de Fonvielle and G. Tissandier.)

CHAPTER VI.

SNOW AND SUNSET—ASCENT OF THE "UNION" 329
(G. Tissandier.)

CHAPTER VII.

WINDY ASCENTS AND DRAGGING 346
(W. de Fonvielle and G. Tissandier.)

CHAPTER VIII.

TWO HOURS OVER PARIS IN A CALM 355
(W. de Fonvielle and G. Tissandier.)

CHAPTER IX.

THE GREAT "CAPTIVE" BALLOON AT LONDON 370
(W. de Fonvielle and G. Tissandier.)

CHAPTER X.

AN ASCENT FROM THE CHAMP DE MARS.—THE "NORTH POLE" BALLOON . 380
(W. de Fonvielle and G. Tissandier.)

CONCLUSION 396

Digitized by Google

LIST OF CHROMO-LITHOGRAPHS.

	To face page
Mirage and Luminous Aureola	*Frontispiece.*
(See p. 220.)	
A Thunderstorm above Fontainebleau, as seen from the Balloon	128
Falling Stars, as observed from the Balloon	262
Shadow and Luminous Effect, as seen from the Balloon	277
After Sunset, as seen from the Balloon	342
A Sunset, as seen from the Balloon	375

Digitized by Google

LIST OF LITHOGRAPHS.

To face page

Path of the Balloon in its ascent from Wolverhampton to Langham, July 17, 1862 43

Path of the Balloon in its ascent from Wolverhampton to Solihull, 18th August, 1862 48

Path of the Balloon in its ascent from Wolverhampton to Cold Weston, 5th Sept., 1862 50

Path of the Balloon in its ascent from the Crystal Palace to Newhaven, 18th April, 1863 60

Path of the Balloon in its ascent from Wolverton to Ely, 26th June, 1863 . 64

Path of the Balloon in its ascent from the Crystal Palace to Epping Forest, 21st July, 1863 72

Path of the Balloon in its ascent from Windsor to near Pulborough, 29th May, 1866 74

Path of the Balloon over London (at night), 2nd October, 1865 80

Temperature of the Air at different heights, 6th April, 1864 86

Course of the Balloon in M. Flammarion's ascent from Paris to Larochefoucault, June 23–24, 1867 178

Course of the Balloon in M. Flammarion's ascent from Paris to Solingen, in Prussia, July 14–15, 1867 199

Double Balloon Ascent of M. G. Tissandier, 8th November, 1868 338

Digitized by Google

LIST OF WOODCUTS.

PART I.

AËRIAL TRAVELS OF MR. GLAISHER.

	PAGE
Portrait of James Glaisher, F.R.S.	xv
Ascent of Mont Blanc	1
Mr. Glaisher in the car	23
Green falls into the sea	25
Blanchard's car	32
The balloon forming a parachute	33
The instruments of Mr. Glaisher arranged in the car	39
Shadow of the balloon on the clouds	45
Above the clouds	47
"We passed through a magnificent cumulus cloud"	48
Beneath a beautiful mass of cumulus clouds	51
Mr. Glaisher insensible at the height of seven miles	55
The pigeons	58
The departure	59
Descent at Newhaven	63
Between two clouds, four miles high	64
Three miles high: "Clouds below us, others on our level at a distance, and yet more above"	65
"Rain fell pattering on the balloon"	69
Nimbi, or rain-clouds, above four miles high	73
The descent	74
The cottage	77
Filling a balloon	78
The suburbs of London in the distance	83
"The moon was shining, but seemed to give no light"	84
"After a time the moon shone with increased brightness"	93
The rainbow	94
"The sun rose, flooding with light the whole extent of cloudland beyond"	97
Charles and De Saussure	101

Digitized by Google

PART II.

TRAVELS OF C. FLAMMARION.

PAGE

The instruments 105
C. Flammarion 107
The sun reflected by the clouds 121
The adieu 122
We touch the top of the trees 131
Leaving Paris in a balloon 132
The Seine and the Marne, as seen from the car in M. Flammarion's second ascent 137
Captive ascent at Barbison 142
Butterflies hovering round the car of the balloon 143
"Absolute silence reigns supreme in all its sad majesty" 149
"It is the Devil himself!" 156
"They are drowned!" 157
A moonlight effect as seen from the balloon by M. Flammarion 163
"But the sceptre of the night is held by Jupiter" 167
A descent among a herd of cattle 171
"The lights of the evening fires were seen in the distant villages". 172
"The sun appears like an immense beacon-light, placed upon layers of snow". 175
"These fires seen from a distance were like lighthouses" 181
The Château of Larochefoucault 185
"Your passports, gentlemen!" 186
The river Seine and the west of Paris—a view from the car of the balloon . 189
The statue of Napoleon as seen from on high 196
Rain in the higher regions 197
Lunar halo observed by M. Flammarion (night of 14-15th July, 1867) . . . 203
A glance into space below, at night 205
The banks of the Meuse 206
"The moon shines forth with peculiar brilliancy" 209
"The orb of day has just appeared, and its golden disc rises among the purple clouds" 213
The satellite balloons 216
Ascent of M. Flammarion from the garden of the Conservatoire 217
Optical phenomenon observed by M. Flammarion 229

PART III.

TRAVELS OF MM. FONVIELLE AND TISSANDIER.

The "Giant" balloon and the "Imperial" balloon 233
W. de Fonvielle 235
"The new-comers fall, pell-mell, one over the other" 243
"'It's the Giant smoking his pipe,' said some one" 249

Digitized by Google

PAGE

Breakfast in the car of the "Giant" 252
Inflation of the captive balloon at the Exhibition 253
"The crows seem frightened at us, and presently fly off precipitately" . . . 259
The peat bogs of La Somme, as seen from the car of the "Swallow" . . . 263
"A peasant succeeds in climbing up to us" 267
"The fixity of the snow-like wreaths of vapour was really very striking" . . . 273
Effect produced by a vault of clouds 285
The valve of the "Entreprenant" balloon 289
Calais as seen through the clouds from the balloon 290
Gaston Tissandier 293
Mirage in the sky, as seen from the balloon 299
Sunset whilst the balloon is at sea 303
Descent of the "Neptune" at Cape Gris-Nez 307
Direction of the aërial currents above Calais, August 17, 1868 309
The "Neptune" in the clouds 310
The "Neptune" at the Conservatoire 311
Circular effect of the clouds 317
"The balloon has burst!" 323
The "Captive" balloon of Paris 328
Departure from the gasworks of La Villette 329
"We rise slowly amidst the snow" 331
"A few vigorous arms lift up the car" 335
"In one bound we pass through the thick layer of cloud" 339
"We fell softly to the ground in a field" 343
The "Union" balloon in the snow 345
"The 'Swallow' balloon, when inflated, lay down upon its side" 346
"The branches of the trees bent beneath the car" 347
Return of the aëronauts 351
Dragging 355
Interior of the "Union" balloon inflated with air 357
The Seine, as seen from the balloon above Asnières 361
Descent of the "Union" balloon in the Cemetery of Clichy 365
Inflation of the balloon with a ventilator 369
Construction of the "Captive" balloon of London 370
The weighing machine of the "Captive" 371
The pulley 371
View of the "Captive" balloon at London 373
Sunset above the Thames, as seen from the "Captive" balloon 377
The car of the "Captive" balloon 379
The "North Pole" balloon in the air 380
The valve of the "North Pole" balloon 384
"The balloon began to bend over" 389
"Thousands of peasants came from great distances to see us" 393
The car of the "North Pole" balloon 395

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PART I.

AËRIAL TRAVELS OF MR. GLAISHER.

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ASCENT OF MONT BLANC.

TRAVELS IN THE AIR.

INTRODUCTION.

I HAVE elsewhere expressed my opinion that the Balloon should be received only as the first principle of some aërial instrument which remains to be suggested. In its present form it is useless for commercial enterprise, and so little adapts itself to our necessities that it might drop into oblivion to-morrow, and we should miss nothing from the conveniences of life. But we can afford to wait, for already it has done for us that which no other power ever accomplished; it has gratified the desire natural to us all to view the earth in a new aspect, and to sustain ourselves in an element hitherto the exclusive domain of birds and insects. We have been enabled to ascend among the phenomena of the heavens, and to exchange conjecture for instrumental facts, recorded at elevations exceeding the highest mountains of the earth.

Doubtless among the earliest aëronauts a disposition arose to estimate unduly the departure gained from our natural endowments, and to forget that the new faculty we had assumed, while opening the boundless regions of the atmosphere as fresh territory to explore, was subject to limitations a century of progress might do little to extend. In the time of Lunardi, a lady writing to a friend about a

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balloon voyage she had recently made, expresses the common feeling of that day when she says that "the idea that I was daring enough to push myself, as I may say, before my time, into the presence of the Deity, inclines me to a species of terror"—an exaggerated sentiment, prompted by the admitted hazard of the enterprise (for Pilâtre de Rozier had lately perished in France, precipitated to the earth by the bursting of his balloon), or dictated by an exultant and almost presumptuous sense of exaltation: for the first voyagers in the air, reminded by no visible boundary that for a few miles only above the earth can we respire, appear to have forgotten that the height to which we can ascend and live has so definite a limitation.

But no method more simple could have been imagined than that by which the aëronaut ascends, and which leaves the observer entire freedom to note the phenomena by which he is surrounded. With the ease of an ascending vapour he rises into the atmosphere, carried by the imprisoned gas, which responds with the alacrity of a sentient being to every external circumstance, and lends obedience to the slightest variation of pressure, temperature, or humidity. The balloon when full and on the earth, with a strong wind, is vehemently agitated, and if a stiff breeze prevail during the progress of inflation, it is for the time almost ungovernable. When prepared for flight it offers the greatest powers of resistance to mechanical control, and, bent on soaring upwards, struggles impatiently to be free.

In a line of perpendicular ascent the balloon has a motion of its own. It therefore rises or falls according to the action of the atmosphere upon the imprisoned gas. The second motion, which, united to the first, carries the balloon out of the perpendicular line on rising, and directs its onward motion in a plane, is not inherent in the balloon, but is due to the external force of horizontal currents which sweep it in the direction of their course, and communicate a compound motion we can neither direct nor calculate. The simple inherent motion we can repeat at will.

I believe the most timorous lose their sense of fear as the balloon ascends and the receding earth is replaced by the vapours of the air; and I refer this confidence chiefly, as has been suggested, to the consciousness of isolation by which the balloon traveller feels more like a part of the machine above than of the world below. Thus situated, he is induced to forget the imperfections of the machine in witnessing the close accordance of its movements with those of the surrounding clouds. The balloon strives to attain a height where it may rest in equilibrium with the air in which it floats; its ascent is checked by allowing gas to escape by the valve, and by the weight of ballast, but

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facilitated by keeping the gas in and discharging the ballast. These are the methods by which it is made to rise or fall at the will of the aëronaut, and the only objection to the frequent employment of the valve and the use of ballast is to be found in the greatly abbreviated life of the balloon and too rapid diminution of its powers which follow.

Up to the time of the Balloon we had no means of ascending by which we could test the conditions of the atmosphere for even a mile above the surface of the earth, apart from the terrestrial influences and the inevitable labour of ascending the mountain side. When, therefore, Messrs. Charles and Robert made their first ascent, and recorded the history of their sensations and the conditions of the atmosphere at various elevations, as the natural incidents and circumstances of their voyage, a practical application of the Balloon was thus spontaneously suggested.

Before Gay-Lussac solicited the French Government for the use of the balloon in which he ascended to the height of 23,000 feet, M. de Saussure, of Geneva, had alone made observations at a height of 15,000 feet and upwards; a distinction he had won by accomplishing the desire of his life, and ascending to the summit of Mont Blanc.

This memorable journey De Saussure performed in the summer of 1787, four years after the first balloon ascent of Messrs. Robert and Charles in a hydrogen balloon from Paris, and seventeen years before Gay-Lussac made his ascent for the advancement of science. The weather was favourable, and the snow compact and hard. Accompanied by his servant and eighteen guides, De Saussure began his journey. There was no difficulty or danger in the early part of the ascent, their footsteps being either on the grass or the rock itself. After six hours' incessant climbing, they found themselves 6,000 feet above the village of Chamouni, from which they started, and 9,500 feet above the level of the sea. At this height, the same to which M. Robert had attained in his balloon, De Saussure and his party prepared to encamp, and slept under a tent on the edge of the glacier of the Montagne de la Côte. By noon the next day they were 2,000 feet above the level of perpetual frost. In the afternoon, after eight hours of climbing, they had arrived at an elevation of 13,300 feet above the level of the sea. They were now on the second of the three tremendous steppes which extend from 800 to 1,300 feet each between Les Grands Mulets and the summit of Mont Blanc. On the second of Les Mulets, De Saussure intended to pass the night. The guides dug out the snow for their lodging, and threw some straw into the bottom of the pit, across which they stretched a tent. Their

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water was frozen, and they had but a small charcoal brazier, which proved quite insufficient to melt snow for twenty persons. When morning came, they prepared again for departure. The cold was excessive, but before breakfast could be obtained it was necessary to melt the snow which also served for the water in their journey to come. They crossed the great ice plain, or Grand Plateau, without difficulty; but the rarefaction of the air began to affect their lungs, and this inconvenience continued to increase at every step. A prolonged rest was made in hopes of recruiting their forces, but with little advantage. They had not gone a dozen steps before they were compelled to halt to recover breath, and in this manner, slowly and with great toil and discomfort, the summit was reached.

"At last," writes De Saussure, "I had arrived at the long-wished-for end of my desires. As the principal points in the view had been before my eyes for the last two hours of this distressing climb, almost as they would appear from the summit, my arrival was by no means a *coup de théâtre;* it did not even give me the pleasure that one might imagine. My keenest impression was one of joy at the cessation of all my troubles and anxieties: for the prolonged struggle and the recollection of the sufferings this victory had cost me produced rather a feeling of irritation. At the very instant that I stood upon the most elevated point of the summit, I stamped my foot on it more with a sensation of anger than pleasure. Besides, my object was not only to reach the crown of the mountain: I had to make such observations and experiments as alone would give any value to the enterprise, and I was afraid I should only be able to accomplish a portion of my intentions. I had already found out, even on the plateau where we slept, that every careful observation in such a rarefied atmosphere is fatiguing, because the breath is held unconsciously; and as the tenuity of the air is obliged to be compensated for by the frequency of respiration, this suspended breathing causes a sensible feeling of uneasiness. I was compelled to rest and pant as much, after regarding one of my instruments attentively, as after having mounted one of the steepest slopes."

De Saussure spent three hours and a half in observations, and after four hours passed on the summit, began with his party to descend. They passed the night on Les Mulets, the third since they left Chamouni, and De Saussure writes: "We supped merrily together and with famous appetites. It was not until then that I really felt pleased at having accomplished the wish of twenty-seven years. At the moment of my reaching the summit I did not feel really satisfied. I was less so when I left it: I only reflected then upon what I had

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not done. But in the stillness of the night, after having recovered from my fatigue, when I went over the observations I had made; when especially I retraced the magnificent expanse of the mountain peaks, which I had carried away engraven in my mind; and when I thought I might accomplish on the Col de Géant what most assuredly I should never do on Mont Blanc, I enjoyed a true and unalloyed satisfaction." The simple narrative of this eminent man is throughout a commentary upon the use of the Balloon for the purpose of vertical ascent. To be carried up with speed and certainty at any number of feet per minute, with instruments complete and carefully prepared for observation, the observer seated as calmly as in his observing room at home, are advantages which speak for themselves. The observations of to-day can be repeated to-morrow, and successively throughout the seasons of the year, and at different hours of the day; and the importance of this repetition is rendered clear by considering of what slight value is a single set of observations, whether in meteorology or any other branch of inquiry, except to appease curiosity, and how little gain to science is one isolated day's experience; and yet to ascend Mont Blanc was the one great fact of De Saussure's life.

The view which offers itself to an aëronaut seated conveniently in the car of a balloon is far more extended than any the eye can embrace within its scope from the summit of a lofty mountain. It is gained without fatigue, but then there is no succession of magnificent scenery which compensates for the toil of the Alpine traveller, and suggests a variety of observations unknown to the voyager of the atmosphere. To the latter, situated at a height above the earth, separated from all communication with it, the scenery on its surface is dwarfed to a level plane, and the whole country appears like a prodigious map spread out beneath his feet. Better than the Alpine traveller he can trace the history of physiological sensations, and pursue the observations of meteorology. In the one case he travels free from the effects of muscular exertion, which makes fatigue so formidable in the higher regions of the earth's scenery, and, apart from all terrestrial influences of soil and temperature, scans the true conditions of the atmosphere.

On looking into the annals of aërostation, I do not find that balloon travellers in general have cared to ascend beyond the height to which De Saussure attained on the summit of Mont Blanc, and the greater number of ascents are within this limit. Most aëronauts have taken care to keep well within recognition of the visible scenery of the earth, and would seem to have been too eager to enjoy the privilege

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of movement, and the varied prospect in any direction they could travel, to wish to prove their capacity for vertical ascents. We have few reliable observations to a great height. High ascents have now and then been attempted by professional aëronauts eager to gain the attention of the public and enlist its sympathy in their results. Voyages in illuminated balloons by night, in weather not always suitable, were performed successively by M. Blanchard, and after him by M. Garnerin, who preceded the late Mr. Green. Beyond the passing sensation of the moment, recorded in the public prints of the day, their ascents have left no permanent trace in the history of the Balloon. The ascent made by M. Charles, after a joint expedition of Messrs. Charles and Robert, is the first experience of value we have to compare with others. It was, we may suppose, the first occasion on which sunset was witnessed a second time in the same day by any living mortal.

On December 1, 1783, having descended and landed his companion, M. Charles determined to ascend alone. It was towards sunset, and ballast could not be readily procured. Without waiting, therefore, M. Charles gave the signal to the peasants, who were holding his machine, to let go; "and I sprang," says M. Charles, "like a bird into the air. In twenty minutes I was 1,500 toises high, out of sight of terrestrial objects. The globe, which had been flaccid, swelled insensibly; I drew the valve from time to time, but still continued to ascend. For myself, though exposed to the open air, I passed in ten minutes from the warmth of spring to the cold of winter: a sharp, dry cold, but not too much to be borne. In the first moment I felt nothing disagreeable in the change. In a few minutes my fingers were benumbed by the cold, so that I could not hold my pen. I was now stationary as to rising and falling, and moved only in a horizontal direction. I rose up in the middle of the car to contemplate the scenery around me. When I left the earth, the sun had set on the valleys; he now rose for me alone; he presently disappeared, and I had the pleasure of seeing him set twice on the same day. I beheld for a few seconds the circumambient air, and the vapours rising from the valleys and rivers. The clouds seemed to rise from the earth, and collect one upon the other, still preserving their usual form, only their colour was grey and monotonous from the want of light in the atmosphere. . . The moon alone enlightened them, and showed me that I had changed my direction twice. Presently I conceived, perhaps a little hastily, the idea of being able to steer my course. In the midst of my delight I felt a violent pain in my right ear and jaw, which I ascribed to the dilatation of the air in the cellular construction of

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those organs as much as to the cold of the external air. I was in a waistcoat and bare-headed; I immediately put on a woollen cap, yet the pain did not go off till I gradually descended."

M. de Meusnier made various calculations as to the height attained by M. Charles, and calculated it to have been at least 9,000 feet. The temperature at the time of starting was 47° on the earth, but in ten minutes had descended to 21°. When M. Charles came down and landed his companion, they were met by the Duc de Chartres and some French noblemen, who had followed on horseback for twenty miles the course of the balloon. A contemporary pamphlet records the particulars of the ascents, and has a postscript to the effect that Messrs. Charles and Robert were arrested on returning to Paris, by order of the King, who, at the suggestion of two of his ecclesiastics, adopted this course to prevent the further endangering the lives of his subjects. "But," adds the writer of the pamphlet, "as great interest is making for them, it is thought they will speedily be discharged."

The height to which M. Charles ascended was thought to be enormous. There had been nothing like it before, and this, the first essay of the hydrogen balloon, brought it at once into public favour and notice. The same elevation, attained one year and ten months later upon the mountain side, made De Saussure console himself under failure, with the thought that he had made more valuable barometric observations and had been higher than any other traveller in Europe. On this occasion he had attempted to ascend Mont Blanc; but the route to the summit remained undiscovered, and after journeying for a day his party were forced to return. Passing the night at an elevation of 9,000 feet, within the walls of a rude hut which had been constructed for the expedition, De Saussure gained his first impressions of these elevated regions. Two mattresses had been deposited within the hut, and an open parasol set against the entrance formed the door. De Saussure says: "As night came on, the sky was completely pure and cloudless; the stars, brilliant indeed, but unscintillating, cast a pale light over the summit of the mountain peaks, sufficient to define their size and distance. The repose and dead silence which reigned in this immeasurable space, increased by the imagination, inspired me almost with terror. It appeared as though I was left living alone in the world, and that I saw its corpse at my feet. I either slept lightly and calmly, or my thoughts were so bright and peaceful I was sorry to slumber. When the parasol was not before the door I could see from my bed the snow, the ice, and the rocks below the cabin, and the rising of the moon gave the most singular appearance to the view." Some of the party

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who shared the hut with De Saussure suffered greatly from the rarefaction of the air, and could not eat anything. The next morning, after an hour's climb, they were forced to return. The snow was soft, and they encountered treacherous drifts and blocks of ice. De Saussure therefore with reluctance abandoned his attempt, the last which was made before the discovery of the true route to the summit.

Whether by mountain ascents or balloon voyages, the traveller who quits the ordinary level of the earth for the upper regions finds two inevitable conditions presented to his endurance, arising respectively from the gradual loss of heat, and the tenuity of the atmosphere. The effects of these conditions will differ, we may assume, with every individual, but certainly are more uniform in their relation to the occupant of a balloon car, who is spared the necessity of exertion and consequent fatigue, than the effects of similar conditions upon a mountain traveller, who, to attain a height to which the aëronaut can ascend in an hour, is subjected to the continuous toil of two successive days, devoted to an ascent which is granted only to a certain degree of strength and activity; for of those who have attempted to reach the summit of Mont Blanc, many have failed through physical inability to endure fatigue. The test, therefore, of the rigorous severity of the upper regions has been experienced by those chiefly of more than average *physique*, men equal to the toil, and who have kept themselves in previous training for the severe exercise involved in the undertaking. But the aëronaut enters upon his expedition unprepared, and attains an elevation not dependent on his physical strength. To this cause, probably, balloon voyages under apparently similar circumstances of elevation show results by no means uniform: a fact which has provoked severe criticism, and has been supposed to arise from the vanity of individuals wishing to prove their experiences greater than those of others. I should be sorry to have to be the champion of all the marvellous histories that have been related; but on looking over a collection of narratives from 1783 to 1835, including the principal aërostatic voyages performed in England, Italy, and France, I believe that, as a rule, authors have written their true experiences, and have correctly recorded their impressions. Aëronauts by trade may at times have been guilty of exaggeration, but the tyro who ascends once and never again is most likely to make demands upon our credulity. It happens thus—that the diminished pressure of the air, and the unfamiliar circumstances of his position, act with far greater force upon an individual who ascends for the first time than ever afterwards. This I can attest,

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having ascended without the slightest inconvenience to a height which used to produce discomfort, and even discoloration of the hands and face, until at length I became so acclimatized to the effects of a more rarefied atmosphere, that I could breathe at an elevation of four miles at least above the earth without inconvenience, and I have no doubt that this faculty of acclimatization might be so developed as to have a very important bearing upon the philosophical uses of balloon ascents. At six and seven miles high, I experienced the limit of our power of breathing in the attenuated atmosphere. More frequent experiments would increase this height, I have little doubt, and artificial appliances might be contrived to continue it higher still. A boundary must exist, but I have little hesitation in saying that it might be removed beyond its present limit. To the terrestrial traveller the conditions of diminished heat and increased tenuity of atmosphere present themselves in the light of problems which have more relation to the influences of the earth than of the atmosphere. Clinging to the earth at every step, and completing his journey upon the highest point of his terrestrial pinnacle, he cannot clear his observations from the influences of the earth; or mark the gradual diminution of temperature conjointly with the amount and degree of cloud present, and estimate, by repeated observations, the extent to which the latter serves as a radiating screen to keep back the heat of the earth within the limits of the lower atmosphere. He cannot mark the fluctuations of temperature through which he rises on a fine but cloudy day, and make them comparable with others taken during cloudless ascents, with no local disturbing causes present to interfere with the law of a decreasing temperature with increase of height. These belong to the balloon voyager alone.

As a rule, the toil of a terrestrial ascent has induced the painful sensations of a rarefied air at an elevation where the aëronaut would have sat at ease, with little or but trifling inconvenience. Thus, at the height to which M. Charles ascended and felt but a slight pain in the muscles of his face and discomfort in his ears, M. Bouret, the friend of De Saussure, suffered so keenly that he was compelled to descend. At a height of three miles I never experienced any annoyance or discomfort; yet there is no ascent, I think, of Mont Blanc in which great inconvenience and severe *pain* have not been felt at a height of 13,000 feet; but then, as before remarked, this is an elevation attained only after two successive days of toil. About this elevation, Dr. Hamel and his party, having passed the Grand Plateau, speak of incessant thick and laboured respiration. They returned,

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however, without reaching the summit, appalled by the catastrophe of an avalanche of snow, which hurried three of the guides into the frightful depths of a crevasse on the ascending slope of Le Mont Maudit. This fatal attempt was made in the early part of the present century, Dr. Hamel being anxious to make the ascent in furtherance of some especial observations taken in compliance with instructions received from the Emperor of Russia. Later still, the same ground was passed over by a party including Sir Francis Talfourd and his son. The effects of cold and diminished pressure are clearly shown in the narrative which is elsewhere published. "The line of our march," observes Sir Francis, "lay up long slopes of snow ascending in a steep inclination before us. There was nothing to vary the toil or the pain, except that, as fatigue crept on, and nature began to discriminate between the stronger and the weaker, our line was no longer continuous, but broken into parties. The rarity of the atmosphere now began to affect us, and as the disorder arising from this cause was more impartial than the distribution of muscular activity, our condition was for a time almost equalized. Violent nausea and headache were experienced by one of our party, while I only felt, in addition to the distress of increasing weakness, the taste or scent of blood in the mouth, as if it were about to burst from the nostrils. We thus reached the Grand Plateau, a long field of snow in the bosom of the highest pinnacles of the mountain."

Until the aëronaut shall have found means to ascend beyond the present limit, he will, I believe, feel no sensation of cold so painful as that of the Alpine traveller. At the extreme height to which I have ascended, the lowest temperature was 12° below zero, or 44° below the freezing-point of water. The cold was intense, but not painfully severe, and no amount of suffering was experienced from this cause; of five pigeons taken up, but one perished. All authorities agree that cold, however intense, is supportable under a calm temperature, whereas a moderate degree of cold with a fresh breeze, or the slightest air stirring, produces the sensation of a very low temperature. The balloon voyager, who feels no wind because he always travels with it, and when sweeping along with the speed of an express train yet meets no current as he cleaves the air and knows no motion, can bear the cold to which he is subjected with little demand on his power of endurance. It is true he is condemned to immovability and to vicissitudes of cold both dry and wet, but these extremes can be guarded against by due precautions of fur and warm clothing. During the period of his voyage the aëronaut may create defence enough against the fluctuations of the atmosphere.

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The subject of cold, physiologically considered with regard to our own sensations, M. Martins has ably treated in his essay, "Du Froid thermométrique et de ses Relations avec le Froid physiologique," on plains and mountains. "Of those who suffer death from cold," M. Martins writes, "let us suppose a single traveller, or a small caravan, wishing to cross one of the '*Cols*' covered with eternal snow which lead from Valais to Piedmont, or from France to Spain. It is winter, or the commencement of spring, or the end of autumn. The journey is long, the time uncertain. The voyagers are not perfectly acquainted with the country. They set out. The sky is covered with cloud, which descends little by little, and envelops them in a thick mist. They walk in the snow, in the track of those travellers who have preceded them; but soon other traces cross those by which they guide themselves, or a recent fall of snow has obliterated every mark. They stop, hesitate, return upon their steps, turn themselves sometimes to the right, sometimes to the left, always making for a summit; they can scarcely see through the fog and mist. The snow begins to fall, not flaky as on the plains, but granulated, dry, and like hail. Driven by the wind it penetrates to the skin through the strongest vestments; striking incessantly the face, it produces a permanent giddiness which soon becomes vertigo. Then the poor traveller, worried, harassed, and not seeing two steps before him, feels an irresistible desire to sleep. He knows that sleep is death; but, lost and despairing, he seeks some rock, and abandoning himself lies down to rise no more. His pulse declines as in a lethargy, and he dies of cold, as one dies of inanition. Moral energy in these moments is the only means of safety. It is necessary at all risks to combat sleep, to walk, to defend oneself against the cold by muscular exercise."

"Jacques Balmat, who was the first to make the ascent of Mont Blanc," observes M. Martins, "knew it well. He was left alone on the Grand Plateau. There he was surprised by night: to mount to the summit was impossible; to redescend in the obscurity equally impossible. He took his post valiantly, and walked about the snow till morning." This man was a native of Chamouni, and had accompanied the party of Dr. Paccard. Being, it is supposed, at the time unpopular among his comrades, he had been neglected by them during the ascent: when they decided to return he had lost sight of them, and his companions, either forgetful of him or determined to descend without him, had returned upon their steps, and he found himself, at an elevation of 14,000 feet, abandoned in the midst of a blinding storm of snow, without food, and but poorly clad. Half dead from the piercing cold, his limbs numbed by the labours he had undergone,

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the poor fellow passed this terrible night as best he could. When morning dawned, Balmat decided upon his part; his feet were frost-bitten and had lost all sensation; but his limbs, benumbed and paralysed, he resolved should carry him to the summit never before attained. Alone he accomplished that which had been denied his treacherous comrades. Alone he traversed the untrodden fields of snow, climbed hitherto inaccessible slopes of ice, and forced his way to the summit by a route but little changed up to the present time. That evening he returned to his village, and, prostrate and despairing of his life, submitted himself to the services of Dr. Paccard, the physician of Chamouni. After an illness of several weeks, in gratitude to the doctor he revealed to him in confidence his secret; and when Balmat was sufficiently recovered, he and Paccard made the first ascent together. They were delighted with their success, and wrote at once to De Saussure at Geneva, who immediately ordered an equipment of mules and guides, to be accompanied and attended by porters and attendants. With the first favourable opportunity of the season, De Saussure made his celebrated ascent, as we have related, Jacques Balmat being appointed chief of the troop of guides. This is the popular narrative, and to his moral energy alone Balmat owed his preservation from death on the night that he was exposed to the piercing and insidious cold of so great an elevation.

A very rapid descent is productive of inevitable discomfort. To this cause probably M. Robert owed the severe pain and inconvenience he experienced at 9,000 feet. The year following, Messrs. Charles and Robert ascended to a height of 14,000 feet. In March 1784, M. Blanchard, the celebrated French aëronaut, made his first ascent from Paris; he mounted high above the clouds, and attained the elevation of 9,600 feet. There is no mention in either case of personal inconvenience. Messrs. Morveau and Bertrand ascended from Dijon in April 1784, when they attained the height of 13,000 feet, and travelled eighteen miles in twenty-five minutes. The temperature of the air descended to 25°. In June 1784, M. Fleurand and Madame Thible ascended at Lyons in a very large fire-balloon, named *Le Gustave*, before the King of Sweden. They reached the height of 8,500 feet, and travelled only two miles in forty-five minutes. In Signor Lunardi's balloon, Mrs. Sage ascended with Mr. Biggin from London; in kneeling down to secure the fastenings of the network in the opening of the gallery, the lady broke the barometer, and they had no measure therefore of the height to which they ascended. It was, however, considerable.

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In July 1784, M. Robert ascended from Paris with the Duc de Chartres and other gentlemen. Within the hydrogen balloon was enclosed a smaller one, filled with common air. They ascended to a height of 5,100 feet, and were greatly beaten about by an eddy or revolving current. The gas expanded; they had no valve, and the inner balloon choked up the aperture of the neck and permitted no escape. In this dilemma, at the mercy of a whirlwind, they decided to make a rent in the outer covering. The Duc de Chartres himself took one of the banners and made two holes in the balloon, which formed an aperture between seven and eight feet in length. The gas escaped in volumes through the open rents, and they came down with great velocity, but no one was injured.

In September 1784, Signor Vincenzo Lunardi ascended, taking with him one small thermometer. He attained no considerable elevation. In January 1785, M. Blanchard and Dr. Jeffries crossed the Channel in a hydrogen balloon from Dover to Calais. From some defect in the gas, or deficiency in its amount, far from being affected by the rarity of the air, they could with difficulty keep themselves at a level above the sea, and to do so were obliged to part with everything in the car, and even take off their clothes and throw them overboard. As they neared the land, however, the balloon rose, and, describing a magnificent arch, carried them over the high ground surrounding Calais, and finally landed them in the Forest of Guiennes. On July 22, Signor Lunardi ascended from Liverpool. The process of filling the balloon was tedious, and the impatience of the populace made it necessary to ascend before the process of inflation could be properly performed. He therefore found himself with barely enough rising power to carry him, and without ballast of any kind; so that when after being becalmed he was gently wafted towards the sea, he had not ballast to throw out to enable him to rise and meet some other current. When suspended over the sea, to lighten his weight he threw down his hat, upon which the balloon rose, and the thermometer fell 3°. The balloon entered a cloud, and, with the thermometer at 50°, Lunardi was surprised at finding himself surrounded with a shower of snow. Being desirous to ascend higher, he threw down his banner, and shortly after took off his coat (the uniform of the Honourable Artillery Company) and threw it away. He then rose majestically, and bore towards the land. Ten minutes later he perceived a thunder-cloud and signs of a gathering storm. To pass from its vicinity he threw down his waistcoat. The temperature had fallen to 32°, and five minutes later fell to 27°; the snow had melted on the top of his balloon, and had trickled down in the form of water. It was now congealed in the

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colder temperature, and hung in icicles round the neck of the balloon; he shook off about a pound's weight, and it fell upon the floor of the gallery, Lunardi looking upon it as the ballast of Providence. The temperature descended to 26°. He now began to descend. It was three minutes to seven, and six minutes after he was safely landed in a cornfield about twelve miles from Liverpool. Here we have a practical commentary upon the necessity of a proper freight of ballast, and of a nicely regulated equilibrium between the balloon and surrounding atmosphere before starting. In the month preceding, M. Pilâtre de Rozier and M. Romain had made their last and fatal voyage from Boulogne. The balloon employed was compound, a small fire-balloon being appended to a hydrogen balloon above. The one set fire to the other, and the aëronauts were precipitated to the earth and killed.

In the beginning of the next century the name of M. Garnerin is closely associated with Balloon history, and replaces that of M. Blanchard. He is chiefly memorable for night ascents with an illuminated balloon. On July 5, 1802, M. Garnerin ascended from Marylebone; the wind was high, but he rose to a height of 7,800 feet, and descended at Chingford, near Epping Forest. His fame as an aëronaut was considerable, and his popularity about this time was at its culminating point with the people of the metropolis, who were in a state of tumult to witness his ascent. This was his twenty-seventh voyage in Europe.

In 1804, Professor Robertson ascended from St. Petersburg, accompanied by the Academician Sacharof. This was purely a scientific voyage, instituted at the request of the Russian Academy, to ascertain the physical state of the atmosphere, and the component parts of it at different determinate heights; also the difference between the results given by vertical ascent and the observations of De Luc, Saussure, Humboldt, and others, on mountains, which it was rightly concluded could not be so free from terrestrial influences as those made in the open air. Among the experiments proposed by the Academy which were to be made at great distances from the earth, the following were included:—The change of rate of evaporation of fluids; the decrease or increase of the magnetic force; the inclination of the magnetic needle; the increase of the power in the solar rays to excite heat; the greater faintness of the colours produced by the prism; the existence or non-existence of electric matter; observations on the influence and changes which the rarefaction of the air occasions in the human body; the flying of birds; the filling with air of exhausted flasks, at each fall of an

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inch in the barometer; and some other chemical and philosophical experiments.

These are the questions to which every voyager in behalf of science is required to add some testimony in reply. In the case of Mr. Robertson, the gyrating movement of the balloon was a difficulty, as it is to all aëronauts, and rendered observations with the deflecting needle almost impossible. With the barometer at 27 inches, Mr. Robertson and M. Sacharof experienced no more inconvenience than a numbness of sensation in their ears, and no alteration of sound, which at 23 inches was the same as on the earth's surface. At the height of 22 inches they were nearly surrounded by fog, the earth appearing enveloped in a smoke-coloured atmosphere which a good telescope failed to penetrate.

Having discharged their ballast and thrown down every available article from the car of the balloon, they deposited for safety their instruments in the centre of a bundle made of their warm clothing, and lowered it together with their grapnel. This proceeding was intended to obviate the breakage consequent on a rough descent. The balloon, so lightened on descending, flew up again to the limit of the cord, but soon effected a safe and gentle landing. The instruments, roughly dragged along the surface of the ground with the package of which they formed a part, were, as might have been expected, injured or broken. These gentlemen made various minute observations of interest, and intelligently recorded all that they witnessed during their ascent. But the instruments could not easily be used in the car of a balloon, and the results required confirmation by subsequent experiments; opportunities also were lost by fog and a clouded atmosphere, and the practical embarrassments of balloon management were severely felt; so that the results are meagre, and show the necessity of system and repeated practice to arrive at results of value.

On October 7, 1803, Count Zambeccari, Dr. Grassati, of Rome, and M. Pascal Andreoli, of Ancona, made a night ascent in a fire-balloon from Bologna. They took with them instruments, and a lantern, by which to see to make observations. The balloon rose with great velocity, and soon attained a height at which Count Zambeccari and Dr. Grassati became insensible. M. Andreoli retained the use of his faculties. About two in the morning they found themselves descending over the waves of the Adriatic; the lantern had gone out, and to light it was a work of no little difficulty. The balloon continued to descend rapidly, and fell, as they anticipated, into the sea. Thoroughly drenched, they succeeded in throwing out ballast until they rose again,

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and passed through three successive regions of cloud, which covered their clothes with rime, and in this situation they became deaf, and could not hear each other speak. About three o'clock the balloon again descended, and was driven by a gust of wind to the coast of Istria, bounding in and out of the sea till eight o'clock in the morning, when one Antonio Bazon picked them up in his ship, and carried them to shore. The balloon, left to itself, went over to the Turks, having first mounted to an amazing height. The most intense interest was excited for the fate of the aëronauts, and bulletins of health were sent from Venice to Bologna. Count Zambeccari suffered most, and was forced to have his fingers incised. The whole of the party, however, ultimately recovered, and Count Zambeccari, in no way intimidated, continued to persevere in making ascents to a considerable height. In the year 1812, accompanied by Signor Bonagna, he ascended from Bologna. On coming down the balloon caught in some high trees and took fire; to avoid being burned they leaped out, when Count Zambeccari was killed, and his companion much injured.

In August 1808, Andreoli and Brioschi ascended at Padua, and rose rapidly to a considerable height. When the barometer had fallen to 15 inches, M. Brioschi felt a violent palpitation of the heart, and when it had reached 12 inches he sank into a state of torpor. M. Andreoli alone could observe the balloon, which rose till the mercury stood at 9 inches; he then found that he could not use his left arm. Soon after this, with the barometer at 8 inches, the balloon is said to have burst with a loud report, and then all came rapidly down together, with safety, near the place of Petrarch's Tomb. The accuracy of this statement has been questioned by the author of "Aërial and Alpine Voyages," who takes it for granted that the rapid escape of heated air would have caused not only a precipitate descent of the whole machine, but the death of the aëronauts. The only part of the account that I feel inclined to question would be that concerning the reading of the barometer, which gives an elevation of more than 30,000 feet. The resistance offered by the air does much in such cases, and it is not an inevitable result that every one must be dashed to pieces. I have myself, under the pressure of an immediate necessity to save the land, fallen the last two miles in four minutes, holding to the valve line to ensure its opening to the full extent and the rapid escape of the gas, and though bruised have not been hurt severely. Mr. Wise, the American aëronaut, has also twice descended to the earth with an exploded balloon. The canvas, torn and rent, acts

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as the mainsail of a ship, and the balloon gyrates through the air in falling. It is not by any means a situation to be coveted, but one, I should be understood to remark, not necessarily involving loss of life, even from so great an elevation as that of the Italian aëronauts. Increase of height accelerates the velocity of the descent, and much increases the hazard of the situation; but it is possible to fall and live. In one of my descents from Wolverhampton, the wind made it difficult and dangerous, and with our utmost efforts the balloon came roughly to the ground: it struck the earth and rebounded again and again, until a long tear became visible, which spread rapidly. The sides of the balloon stood out like wings, but the upper part remained, until finally a great rent passed up from neck to valve, when I fully expected all would drop down. But for some little time after this the great valve, with its heavy springs, remained fifty feet high in the air, whilst the whole balloon opened out in one immense sheet, and, kite-like, kept up perhaps for rather more than a minute, though it appeared to me a much longer time. It then gradually fell to the ground. That it did not fall more rapidly was due to the pressure of the atmosphere. We had a few bruises, but none of any importance, and were spared the general reversal of our effects which happened to Mr. Wise, who alighted with his car bottom upwards. If we therefore, in consideration of our own and other authenticated experiences, allow that the Italian aëronauts might have survived the catastrophe of their machine, and that the elevation they attained was nearly, if not quite, equal to that which they record, I may remark that the remainder of their statement bears comparison with the effect of rarefied atmosphere upon others. Thus, Signor Andreoli, of whose ascents there are frequent mention, and who was more inured probably to the higher regions, suffered less than Signor Brioschi, and observed the barometer after his companion became insensible. At 15 inches, Signor Brioschi found his respiration seriously affected. At 15 inches, I began to pant for breath. At 12 inches, Signor Brioschi became insensible,—that is, at about 23,000 feet above the earth, the same height to which Gay-Lussac attained without inconvenience. At 9 inches of the barometer, that is, at 29,000 feet, Signor Andreoli, more seasoned than his companion, found only that he could not use his left arm, and was able to observe that the balloon was fully inflated. The balloon employed was doubtless one of Montgolfier's filled with heated air, as such were principally in use in Italy. It ascended with great rapidity, and, unless they carried fire, must have cooled and descended within a very short period of time, without travelling far from the

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place of ascent. Leaving it an open question whether or no the barometer reading may have given too great altitudes, we may fairly suppose that Signor Andreoli, of whom frequent mention is made, had become enabled to support the greater rarity of the air, whilst his companion is shown to have yielded at an elevation less than that at which, when seasoned, I first became seriously affected. I am inclined to accept the statement as it is written, and the facts described are certainly in accordance with other experiences. It may be argued that Gay-Lussac felt no inconvenience at the height at which Signor Brioschi fainted; but the French philosopher ascended in a hydrogen balloon, slowly, to take note of the instrumental phenomena committed to his charge, and there is every reason to believe that Signors Brioschi and Andreoli ascended very rapidly to a great height, the sudden effect of which, as I have already said, is a shock which the system is unable to support.

In August 1811, Mr. Sadler and Mr. Henry Beaufoy ascended from Hackney; they attained an elevation no higher than sufficient to view the landscape of the earth spread out beneath them like an open map, and were not therefore subject to the test of physiological sensations. The idea of unlimited freedom conveyed by the sense of floating in the invisible medium which surrounds the aëronaut; the total unconsciousness of movement, and the sudden sinking away of the earth and the people on it; the silence of the upper regions succeeding instantaneously to the shouts of the spectators and the noise and turmoil around the car, are among the first impressions which occurred to Mr. Beaufoy.

In 1812, Mr. Sadler ascended at Dublin to cross to Liverpool, but meeting with an adverse current, he resolved to descend into the sea. To escape from drowning, and effect the disablement of his balloon, he caused the crew of a ship to run her bowsprit through it, and then to take him on board. Mr. Sadler, junior, ascended from the Green Park, and with difficulty saved his life. Not only did the valve become frozen, but the net burst at the top, and the silken covering of the balloon began gradually protruding through it. To save himself from being precipitated to the earth, he tied the long silken neck of the balloon round his body. After being carried to a great height into the upper regions, and almost frozen with the cold, he came down at length near Gravesend.

In 1832, Dr. Foster ascended with Mr. Green from Chelmsford, with the idea of making some further observations on clouds, in addition to those already made on Alpine excursions; also to test by personal sensation the effect of the higher regions of the air upon the

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organs of hearing. They ascended slowly, and were for a time becalmed. "It was towards evening, and looking in the direction of Maldon river, and hovering over its marshy land, we saw," observes Dr. Foster, "what had evidently been a cumulus now subsiding into a stratus, or white evening mist, stretching in such a manner over the ground in its descent, that we at first took it for smoke. Higher up there were cumuli in the air, and uniform haze, and some warm clouds. The beauty and extent of prospect now increased. All earthly sounds ceased as soon as we had got above the breeze which swept above the surface of the ground, where in a region comparatively calm, and lighter than it was below, we were conscious of no motion whatever. I presently felt a slight movement, and heard the great buoyant balloon above us make a noise, as if touched by the wind. On adverting to the cause, we found that we had got into another current, which wafted us back again towards Chelmsford as we moved round with the oscillating machine. . . . I remember, in crossing to France," continues Dr. Foster, "the first experience of a steamboat paddling across the level brine like a fish was a curious phenomenon, having before been only conveyed by sailing vessels. But this new-born Leviathan of the deep is nothing to this Pegasus of the air, neither is the sensation produced by a balloon in motion at all comparable to that of a balloon at rest."

The most remarkable ascent of the century was that fitted out by Robert Hollond, Esq., M.P.; Mr. Green's balloon, afterwards known as the great *Nassau*, was employed for the expedition, and provided with every imaginable requisite, and provisions to last a fortnight, or longer if need be. On the afternoon of Monday, Nov. 7, 1836, it left Vauxhall Gardens. The party consisted of Mr. Green and Mr. Robert Hollond, the projector of the enterprise, accompanied by Mr. Monck Mason. It was one o'clock when they left the earth, and, in obedience to the prevailing current, were wafted gently along. By the fading light of the winter day they found themselves leaving land, and vertically placed above the breakers on the beach beneath. Throughout the night, in utter darkness, they voyaged for hours above a dense stratum of cloud, through breaks of which an occasional glimmer of light from the fires on the surface of the earth alone could penetrate by a partial glimpse. As morning dawned the aspect of the country they were traversing afforded them no knowledge of their bearing, and at ten minutes past five they gained their greatest elevation, and mounted to a height of 12,000 feet. At a quarter to six they were brought into full view of the sun, and presently descending, to rise again, enjoyed the spectacle of a sunrise above the clouds. As the sun

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gained power they anxiously endeavoured to gain some knowledge of the position they occupied above the earth, and, in ignorance of the speed with which they had been journeying and of the distance traversed, began to surmise that they might already have passed the limit of that part of Europe where they might expect to find the accommodation and conveniences necessary for their comfort and the safety of the balloon. The large tracts of snow beneath them suggested the plains of Poland or the steppes of Russia; they therefore proposed to descend without delay, and, lowering the grapnel, came safely to earth, passing the gentle declivity of a wooded valley, and descending into the bosom of the trees which capped its summit. Bespeaking the assistance of people near, the balloon was speedily secured, and they learned that they had descended in the duchy of Nassau, about two leagues from the town of Weilburg. The journey had lasted eighteen hours, and was thus brought to a safe and agreeable termination. Mr. Monck Mason drew up an able account of the expedition, which he subsequently published in his "History of Aërostation," a work to which I refer my readers who may feel interested in further particulars of the voyage.

Had I attempted a consecutive narrative of balloon ascents (instead of calling attention to those only which were important on account of their elevation), the names of Pilâtre de Rozier, the first aëronaut, and Blanchard, the first aërial voyager by profession, would have found greater prominence.

In the use of the balloon, distinction must be made between travelling for miles horizontally over a surface of country which is disclosed like a grand natural panorama to the eye of the voyager, and ascending perpendicularly to the greatest altitude within the capacity of the machine and the limits of human life. Vertical and horizontal explorations of the air have each a range of experiences of their own; the latter give rise to personal enjoyment chiefly, while the former add to our knowledge of hitherto unexplored territory.

For vertical motions only is the balloon manageable. With its capacity measured and weight determined, its ascending power can be calculated, and the aëronaut may nerve himself to brave the vicissitudes of a certain elevation, and, if inured to the work of observation, make every fresh ascent an epoch in discovery. To Mr. Green is due the employment of coal gas, which has long superseded the use of hydrogen. The filling of a balloon, therefore, is no longer the tedious and uncertain operation it was formerly, extending sometimes over several days, but is performed with ease and certainty in a few hours

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and at a moderate cost. The comparatively easy management of a balloon so filled in the hands of a practised aëronaut, under whose guidance for a matter of £ *s. d.* one can sit securely and for an hour or two enjoy the delight of an aërial voyage within sight of earth, is one reason, I believe, why the balloon has gradually degenerated into an instrument of popular exhibition and passing amusement, so that its striking characteristics and important bearing are in danger of fading completely out of view.

To guide the balloon in any horizontal direction appears now as far from practicable as it has ever been. We start from a given point to go where chance directs. The compass we carry with us, not that we may steer our course along a given route, but trace by it the erratic and ungoverned movements of the machine that carries us. We traverse perhaps the segment of a huge circle, the line of our path in space. We proceed and return, advance onward, now gently, now with velocity. We sit in the car without the slightest knowledge of the earth's landscape hidden beneath the vapours of the air. The voyage itself is to last many hours, if all things should be favourable. Where, let us ask, is the practical advantage of such a machine? To what use can it be converted? Are we wrong in supposing it to be a first principle which requires yet to be engrafted into some mechanism which shall be more subordinate to the requirements of life?

It is not to be supposed that additional frequency of respiration in an attenuated air makes amends for the want of oxygen. Those who have felt the continued dryness of the throat, which is parched so that to swallow is painful, are sensible to the contrary; but the death it produces is painless, and asphyxia steals away the life of the human being as he moves above, suspended in mid-air, as stealthily as cold does that of the mountain traveller, who, benumbed and insensible to suffering, yields to the lethargy of approaching sleep, and reposes to wake no more. These two powers rule respectively the upper regions of the atmosphere, whether we seek to approach them by vertical ascent or by the steepest mountains, and the element we live in warns back the adventurous traveller to the limits appointed to human life and physical exertion.

Let us take the Balloon as we now find it, and apply it to the uses of vertical ascent; let us make it subservient to the purposes of war, an instrument of legitimate strategy; or employ it to ascend to the verge of our lower atmosphere; and, as it is, the balloon will claim its place among the most important of human inventions, even if it remain an isolated power, and should never become engrafted as the ruling principle of the mechanism we have yet to seek.

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The Balloon, considered as an instrument for vertical exploration, presents itself to us under a variety of aspects, each one of which is fertile in suggestions. Regarding the atmosphere as the great laboratory of changes which contain the germ of future discoveries, to belong respectively as they unfold to the chemist and the meteorologist, the physical relation to animal life of different heights; the form of death which at certain elevations waits to accomplish its destruction; the effect of diminished pressure upon individuals similarly placed; the comparison of mountain ascents with the experiences of aëronauts, are some of the questions which suggest themselves, and faintly indicate inquiries which naturally ally themselves to the course of balloon experiments. Sufficiently varied and important, they will be seen to rank the Balloon as a valuable aid to the uses of philosophy, and rescue it from the impending degradation of continuing a toy, fit only to be exhibited, or to administer to the pleasures of the curious and lovers of adventure.

We can also make use of it to determine the proportions of the gaseous elements we breathe. Do not the waves of the aërial ocean contain, within their nameless shores, a thousand discoveries destined to be developed in the hands of chemists, meteorologists, and physicists? Have we not to study the manner in which the vital functions are accomplished at different heights, and the way in which death takes possession of the creatures whom we transport to these remote regions? Have we not to compare the different effects of the diminution of pressure on individuals placed in identical condition in the car of the same balloon?

When the Balloon was invented, the great Lavoisier was charged by the Academy of Sciences to draw up a report in order to estimate the value of this unexpected discovery. After having minutely described the ascents at which he was present, the illustrious chemist stopped, appalled in some measure at the multitude of the problems the Balloon would help to solve, and the series of uses of which it seemed susceptible. I shall imitate his reserve; for it seems unnecessary to justify further the attempt to make the Balloon a philosophical instrument, instead of an object of exhibition, or a vehicle for carrying into the higher regions of the air excursionists desirous of excitement, mere seekers after adventure.

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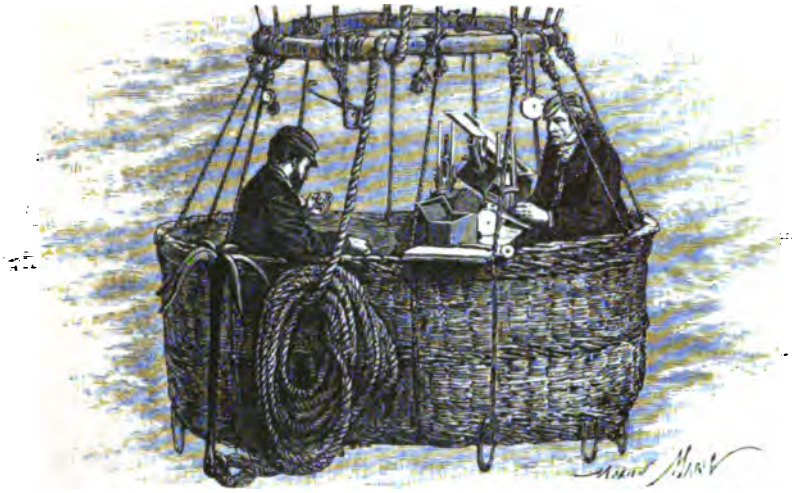

MR. GLAISHER IN THE CAR.

CHAPTER I.

THE FIRST SCIENTIFIC ASCENTS IN ENGLAND.

THERE are no frontiers in the reign of thought, and the conquests of the human mind belong to all the world; yet each civilized nation is called upon to give its contingent to the great work of the study of Nature, and to choose those branches which are most suited to its genius.

France has given the Balloon to the world, but her work is still incomplete, and the conquest of Charles and Montgolfier remains undeveloped. It is not, however, my intention to describe the attempts which have been made to this end, or discuss the value of the Balloon as a first step towards the solution of the problem of aërial locomotion; I desire only to describe the principal results of my own aëronautical excursions, after briefly alluding to the observations of my predecessors in this field of inquiry.

The first persons in England who devoted themselves to aërial navigation were foreigners. The philosopher Tiberius Cavallo and the diplomatist Vincent Lunardi were both Italians. But from the time when Lunardi inaugurated balloon ascents to the present day, it may be truly said that balloons have remained popular with us; not only have noblemen and gentlemen shown a taste for aërial journeys, but men of science have followed up with avidity the great experi-

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ments made on the Continent, and several attempts have been made in England, both by free and captive balloons, to study systematically the phenomena of the atmosphere.

In 1838 and 1850, Mr. Rush ascended several times with Mr. Green, and made some observations mainly on humidity. Public attention was aroused to a certain extent, but the ascents were chiefly known from an incident which occurred at the end of one of them. The balloon descended in the sea near Sheerness, and the car was dragged through the water with considerable rapidity; the balloon acting as a kite. Mr. Green therefore threw out the grapnel, which caught in a sunken wreck, and detained the balloon till a boat came up and secured the voyagers. A volley of musketry was fired into the balloon to admit of the escape of the gas, and it was ultimately secured.

Soon after the discovery of the Balloon, a desire arose for experiments in the higher regions of the air. The first experiments, as I have previously stated, were made at St. Petersburg, by command of the Emperor of Russia, by Mr. Robertson, in the years 1803 and 1804, but no important results were obtained.

In the year 1804 two experiments were made at Paris: the first on August 31, by Gay-Lussac and Biot. These gentlemen ascended to the height of 13,000 feet, but did not commence their observations till they were 7,000 feet high. Their experiments in magnetism, electricity, or galvanism, gave results identical with those made on the earth—a source of much disappointment to every one.

It was then supposed that they had not ascended high enough, and Gay-Lussac resolved to go alone, with the view of reaching a greater elevation. This he succeeded in doing on the 15th of September following, when he reached a height of 23,000 feet, and found a decline of temperature from 82° to 15°; almost confirming the theory of a decline of temperature of 1° in 300 feet of elevation. The sky was very blue, and the air was found to be very dry. A magnet took a longer time to vibrate than on the earth. He filled two bottles with air from the higher regions, which on analysis was found to be in its component parts the same as the lower air.

Two years after this, the Astronomer Royal of Naples, Carlo Brioschi, wished to ascend higher than Gay-Lussac, but this he was unable to do in consequence of the Balloon bursting. After this no attempt was made till the year 1843, when the British Association appointed a committee and voted a sum of money for experiments by means of captive balloons. Several committees were subsequently appointed, and out of the limited resources of the Association considerable sums

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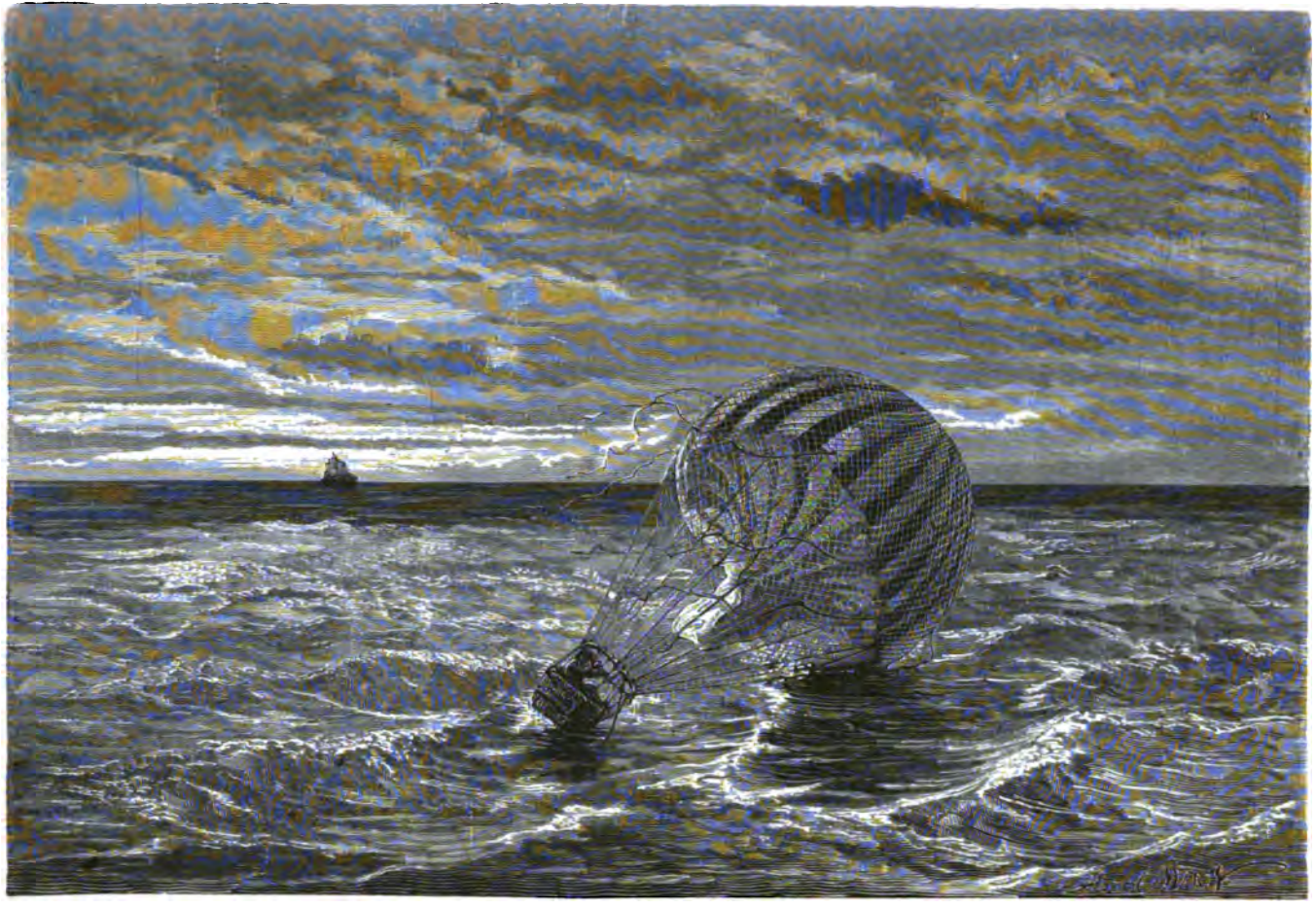

GREEN FALLS INTO THE SEA.

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of money were granted for experiments by means of balloons; but no good results were obtained. This want of success ought neither to discourage nor astonish us; captive ascents, though easy enough when directed by experienced aëronauts with proper appliances, present inextricable difficulties to novices unaccustomed to the disappointments of aërial navigation.

In the year 1850 MM. Bixio and Barral conceived the project of ascending to a height of 30,000 to 40,000 feet, in order to study the many atmospheric phenomena as yet imperfectly known. On June 29th in that year, a balloon was filled in the garden of the Observatory at Paris with *pure hydrogen gas*. The weather was bad—a torrent of rain fell; MM. Bixio and Barral, and the aëronaut, placed themselves in the car without testing the ascending power of the balloon, and darted into the air like an arrow, as described by the spectators, so that in two minutes they were lost in the clouds. At a height of 5,000 feet the gas in the balloon expanded with great force against the netting, which proved to be too small. The balloon became full, and descending upon the voyagers covered them completely as they were seated in the car, which unfortunately was suspended by cords much too short. In this difficult situation, one of them, in his efforts to disengage the cord from the valve, made an opening in the lower part of the balloon, from which the gas escaping at the height of their heads, occasioned them continued illness. Then they found that the balloon was torn and they were falling fast. They threw away everything they could, and came to the earth in a vineyard, having left it only forty-seven minutes previously. A mass of clouds 9,000 feet in thickness was passed through. The decrease of temperature up to 19,000 feet, the highest point reached, seemed to confirm the results obtained by Gay-Lussac in 1804.

In the following month, July 27, the filling of the balloon was commenced early in the morning. It proved to be a long operation, occupying till nearly two o'clock; then heavy rain fell, the sky became overcast, and it was after four when they left the earth. They soon entered a cloud at 7,000 or 8,000 feet, which proved to be fully 15,000 feet in thickness; they never, however, reached its highest point, for when at 4h. 50m. the height of 23,000 feet was reached, they began to descend, owing to a tear which was then found in the balloon. After vainly attempting to check this involuntary descent, they reached the earth at 5h. 30m.

On approaching the limit of this cloud of 15,000 feet in thickness, the blue sky was seen through an opening in the surrounding vapour. The polariscope, when directed towards this point, showed an intense

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polarization, but when directed to the side, away from the opening, there was no polarization.

An interesting optical phenomenon was observed in this ascent. When near their highest point, the bed of the clouds which covered the balloon having become less dense, the two observers saw the sun dim and quite white, and also at the same time a second sun reflected as from a sheet of water, probably formed by the reflection of luminous rays on horizontal sides of crystal ice floating in the clouds.

The most extraordinary and unexpected result, however, observed in this ascent was the great change of temperature. At the height of about 19,000 feet the temperature was 15°, but in the next 2,000 feet it fell to minus 39°. This wonderful change was experienced in the clouds. What, we may ask, can the constituents of such a cloud then be? In this voyage a height short of Gay-Lussac's by 50 feet was reached, but a temperature lower by 54° was recorded, and the clothes of the observers were covered with fine needles of ice. From this time until quite recently no ascents have been made in France in the cause of science.

In the year 1852 Mr. Welsh, of the Kew Observatory, made, under the auspices of the British Association, four ascents in the great *Nassau* balloon, with the veteran aëronaut Mr. Green, who had then an experience derived from several hundred ascents.

In August, October, and November he reached the respective heights of 19,500, 19,100, 12,640, and 22,930 feet, and in each ascent made a valuable series of observations.

The facts recorded by Gay-Lussac, relative to the decline of temperature with increase of elevation, appeared to confirm the law which had been derived from observations made on mountain-sides, viz. a decrease of 1° for every increase of 300 feet of elevation; and the deductions of Mr. Welsh from his experiments tended to the confirmation of the same law, with some modifications.

The results of Welsh's observations were published in the Philosophical Transactions of the Royal Society for the year 1853, and afterwards in the *Bulletin Géographique de Dr. Petermann* for 1856.

When these ascents were made, they excited the greatest public interest. I watched Mr. Welsh's fourth ascent throughout, from the roof of the Royal Observatory at Greenwich, with a good telescope. The day was fine and the air clear, and I was surprised at the facility with which I could follow every movement of the balloon, from its departure to its descent. During the whole time that the balloon was in the air, and while it traversed a course of fifty-seven miles in the direction E.S.E., I never lost sight of it for a moment. I saw it rise

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from Vauxhall at 2h. 22m., and descend at 3h. 40m., at a place which I afterwards learned was near Folkestone. It was this circumstance which notably influenced me in my desire for balloon observations, and which led me to believe in the possibility of combining terrestrial observations with those made in the balloon, and thereby determining the height of the balloon at different times, independently of observations made in the car. But in my own ascents I never was able to organize, to my satisfaction, the telescopic observations of the balloon from the earth, so as to verify the heights determined from my own observations.

This, however, was not the first time aërial physics had engaged my attention. A taste for these studies was first developed during my residence in Ireland in the years 1829 and 1830. In these years I was often enveloped in fog for entire weeks, first on the mountain Bencor, in Galway, and afterwards upon the summit of the Keeper Mountain, near Limerick. At this time I was engaged on the principal triangulation of the Trigonometrical Survey of Ireland, and in the performance of my duty I was often compelled to remain, sometimes for long periods, above, or enveloped in cloud. I was thus led to study the colours of the sky, the delicate tints of the clouds, the motion of opaque masses, the forms of the crystals of snow. On leaving the Survey, and entering the Observatory of Cambridge, and afterwards that of Greenwich, my taste did not change. Often between astronomical observations I have watched with great interest the forms of the clouds, and often, when a barrier of cloud has suddenly concealed the stars from view, I have wished to know the cause of their rapid formation, and the processes in action around them.

The illness of Mr. Welsh interrupted his series of experiments, and scientific ascents ceased to occupy public attention. But the British Association did not lose their interest in aërial experiments, and Colonel Sykes, M.P. for Aberdeen, again brought the subject before the meeting of the British Association at Leeds in 1858, and obtained the appointment of an influential committee. The resources of the Association, composed exclusively of the contributions of its members, are devoted mainly to taking the initiative in important and hitherto unexplored departments of science, and out of these limited means the necessary grants for these scientific balloon ascents were made, the chief expenses being the hire of the balloon, the payment of the aëronaut for its management, and the cost of the gas. Several of the members of the committee had already made balloon ascents with Mr. Green. They were, therefore, well able to appreciate the importance of observations made in and above the clouds. It was at first

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arranged that Mr. Green should direct the ascents, and that the observations should be taken by young men. Mr. Green, who was born in 1784, the same year as the introduction of balloons into England, was then seventy-four years of age.

I gave two young observers all the instructions I could in respect to the observations to be taken, and explained to them all the precautions that a long life devoted to observations suggested to me. On the 15th August, 1859, the members of the committee met at Wolverhampton, in order to assist at the first departure of the balloon. This town was selected on account of its central position. It was subsequently the point of departure of some of my most successful expeditions.

The weather was fine when the filling of the great *Nassau* balloon was begun; but the wind arose, and many accidents happened which prevented the filling of the balloon taking place, so that the ascent was deferred till the 16th of August. The committee was again at its post on this day, but, as it proved, only to see an aërial shipwreck. When many thousands of feet of gas had been introduced into the balloon, the wind arose and blew it with such violence that it was torn, and all the gas escaped.

Mr. Green, having examined the injury, said it would take many days to repair, and as the meeting of the Association was approaching, it was resolved to defer the experiment. Such accidents would be impossible, or at least of extremely rare occurrence, if a less barbarous mode of inflating balloons than filling them slowly in the open air were adopted.

Mr. Green was greatly distressed at this accident, which was due to no fault of his; for to it was attributable the interruption of a series of experiments which, he calculated, would have placed aërial navigation in its proper place, and raised it from the inferior position in which he found it. Having had, he said, all his life to contend with similar difficulties at places of amusement only, he was more than any one else aware of the importance of experiments made under irreproachable conditions, and placed under the patronage of learned men; and he wished to close his career under such circumstances.

The career of Green began in the year 1821, at the coronation of George IV.; it continued for thirty-six years, during which he made nearly 1,400 ascents. Three times he crossed the sea; twice he fell into it. He obtained a large experience, and his accounts are worthy of all confidence; but, unfortunately, his education was not sufficiently good to make him a competent observer in the higher regions of the atmosphere. However, he improved the general management of

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balloons in many particulars—his guide-rope in aërial navigation, particularly of use in crossing seas, and the introduction of carburetted gas in the place of hydrogen, are worthy of mention. He died in the year 1870, in his eighty-sixth year.

The Balloon Committee, though discouraged by these frequent delays, resolved to organize four ascents from Wolverhampton. It was decided that they should be to the height of four or five miles, in order to verify the facts announced by Gay-Lussac and MM. Bixio and Barral; but on inquiry it was found that no balloon that would contain a sufficient quantity of gas to enable an observer to ascend so high was to be obtained in England. The largest, it was understood, was the *Royal Cremorne*, which would hold nearly 50,000 feet. This balloon the committee therefore obtained, and Mr. Lithgoe, who had made nearly one hundred ascents, principally from Cremorne, was employed as aëronaut. Ballooning had been for many years pursued only as a trade, and there was no choice whatever either of balloons or aëronauts. Notwithstanding the desire which I had always felt for observations at high altitudes, I had decided not to take the observations myself, but only to give all necessary instructions in the use of instruments and precautions necessary to be taken.

As the gentleman who first engaged to be the observer declined, the observations were entrusted to Mr. Criswick, assistant at the Observatory at Greenwich, who alone was to accompany the aëronaut. The space within the boundary of the Gas Works was selected for inflating the balloon. Before the hour of the ascent, the members of the committee, with Lord Wrottesley and Mr. W. Fairbairn, the President of the British Association, were on the ground.

At 1h. 4m. the balloon ascended slowly and steadily. After remaining nearly stationary for a few minutes sand was thrown out, and the height of one mile was reached; in thirteen minutes it passed out of sight; but little more than a mile had been reached when the balloon descended from sheer inanition. It proved to be full of minute holes, and was quite useless, as were the observations made, which contradicted themselves. The disappointment was great. Arrangements had been made for meteorological observations every few minutes, at thirty different places. This check to the proceedings was very serious, and naturally disgusted many with aëronautical experiences. Colonel Sykes and the committee were bitterly disappointed, but met in consultation at Wrottesley Hall. Mr. Lithgoe admitted that the balloon had been in use thirty years, and was worn out; he advised application to be made to Mr. Coxwell for the use of his *Mars* balloon.

I must ask pardon of the reader for entering into all these details,

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but they show the greatness of the difficulties with which such investigations are too often surrounded. One would have believed that the real difficulties would have been met with in the air, but, on the contrary, the greatest difficulties had to be overcome on the earth.

The *Mars* was found to be injured. Several tailors were set to repair it, but it was found that their combined labour could not effect the reparation in less than several days, and even then Mr. Coxwell said he could not pledge himself to make a safe ascent; he offered, however, to construct a new balloon, larger than any previously made. It was in the car of this balloon that by far the greater number of my experiments were subsequently made.

BLANCHARD'S CAR.

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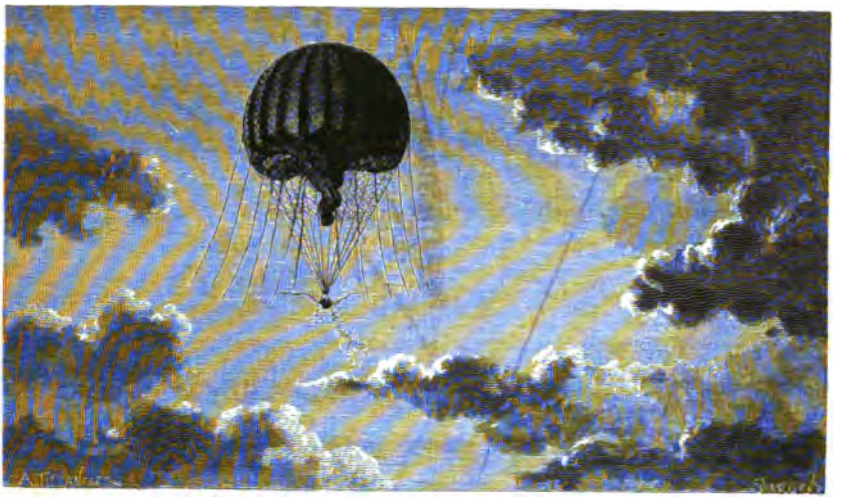

THE BALLOON FORMING A PARACHUTE.

CHAPTER II.

MY FIRST ASCENT—WOLVERHAMPTON.

JULY 17, 1862.

NOTWITHSTANDING all these accumulated difficulties and the efforts I had been obliged to make to overcome them, I found that in spite of myself I was pledged both in the eyes of the public and the British Association to produce some results in return for the money expended. I therefore offered to make the observations myself. The three or four months which elapsed between the abortive attempt of the *Mars* and my first ascent were devoted to preparatory studies and experiments; for I was occupied with the construction and management of the apparatus which I intended to take with me. I also accustomed myself to the use and manipulation of the instruments in a limited space, and considered how best to group them on a board such as would have to serve me for a table in the car of the great balloon; so that when the day for the ascent came, I was able to imagine that I was not making my aërial *début*.

In spite of the experience which I had of observations on the earth, and in spite of the time which I had devoted to this first ascent, I had neglected a great number of useful precautions, and encumbered myself with some superfluous apparatus; in short, I was able to perfect without cessation my apparatus in every successive ascent. I

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hope that the experience which I have acquired, sometimes to my cost, will show how much those philosophers are in error who think that observations in the higher regions can be made well enough by the first observer that comes.

The novelty of the situation, the rapidity with which all the observations must be made, and the smallness of the space at command, require that the observer should have previously had considerable practice in the use of the instruments under all circumstances. I may mention also that I experienced great anxiety when I reflected that at every instant I might be failing to observe very important phenomena, and that I was excessively fatigued by the extraordinary attention to which I found myself condemned by the fear of not being ready when the moment came to observe a phenomenon which perhaps no human eye had contemplated before.

The objects to which the Committee of the British Association resolved to devote their principal attention were, primarily:—To determine the temperature of the air and its hygrometrical states, at different elevations, to as great a height as possible; to determine the rate of decrease of temperature with increase of elevation, and to ascertain whether the results obtained by observations on mountain-sides, viz. a lowering of temperature of one degree for every increase of elevation of 300 feet, be true or not; also to investigate the distribution of the water in the invisible shape of vapours, in the air below the clouds, in the clouds, and above them at different elevations. Secondarily:—

1. To determine the temperature of the dew-point by Daniell's dew-point hygrometer, by Regnault's condensing hygrometer, and by dry and wet bulb thermometers as ordinarily used, as well as when under the influence of the aspirator (so that considerable volumes of air were made to pass over both their bulbs) at different elevations, as high as possible, but particularly up to those heights where man may be resident, or where troops may be located (as in the high lands and plains of India), with the view of ascertaining what confidence may be placed in the use of the dry and wet bulb thermometers at those elevations, by comparison with the results as found from them, and with those found directly by Daniell's and Regnault's hygrometers; also to compare the results as found from the two hygrometers.

2. To compare the readings of an aneroid barometer with those of a mercurial barometer up to five miles.

3. To examine the electrical condition of the air at different heights.

4. To determine the oxygenic condition of the atmosphere by means of ozone papers.

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5. To determine whether the horizontal intensity of the earth's magnetism was less or greater with elevation, by the time of vibration of a magnet.

6. To determine whether the solar spectrum, when viewed from the earth, and far above it, exhibited any difference, and whether there were a greater or less number of dark lines crossing it, particularly near sunset.

7. To collect air at different elevations.

8. To note the height and kind of clouds and their density and thickness.

9. To determine the rate and direction of different currents in the atmosphere.

10. To make observations on sound.

11. To make observations on solar radiation at different heights.

12. To determine the actinic effects of the sun at different elevations by means of Herschel's actinometer.

13. To note atmospherical phenomena in general, and to make general observations.

Every one knows that *the pressure of the atmosphere* is measured by means of the barometer. A column of air extending to its limit of the same area as the barometer tube is balanced by the column of mercury in the tube; and if we weigh the mercury, we know the weight or pressure of the column of atmosphere upon that area. If the area of the barometer tube be one square inch, then this would tell us the pressure of the atmosphere on one square inch. The length of a column of mercury thus balanced by the atmosphere, near the level of the sea, is usually about 30 inches, and if this be weighed it will be found to be nearly 15 lbs.: therefore the atmospheric pressure on every square inch of surface is about 15 lbs.—just one-half as many pounds as the number of inches which expresses the height of the column of mercury.

Now, in ascending into the air, part of the atmosphere is below, and part above: the barometer therefore has to balance that which is above only, and will therefore read less.

At the height of three miles and three-quarters, the barometer will read about 15 inches: there is therefore as much atmosphere above this point as there is below, and the pressure on a square inch is 7½ lbs.

At a height of between five and six miles from the earth, the barometer reading will be about ten inches: one-third of the whole atmosphere is then above, and two-thirds beneath; and the pressure on a square inch is reduced to 5 lbs.

The reading of the barometer varies with the altitude at which it

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is observed, and indicates by its increasing or decreasing readings corresponding changes in the pressure of the atmosphere.

At the height of	1 mile	the barometer reading is	24·7 in.
„	2 miles	„	20·3 „
„	3 „	„	16·7 „
„	4 „	„	13·7 „
„	5 „	„	11·3 „
„	10 „	„	4·2 „
„	15 „	„	1·6 „
„	20 „	„	1·0 „ less.

By the reading of the barometer in the balloon, the distance from the earth is known; and if the balloon be situated above clouds, or in a fog, the reading of the barometer indicates the near approach of the earth, and acts as a warning to the occupants of the car to prepare accordingly. In addition to this temporary use, the readings combined with those of temperature enable us to calculate the height of the balloon at every instant at which such readings have been taken.

The temperature of the dew-point also deserves a few explanatory words.

There is always mixed with the air a certain quantity of water, in the invisible shape of vapour, sometimes more, sometimes less; but there is a definite amount which saturates the air at every temperature, though this amount varies considerably with different temperatures.

A cubic foot of air at the temperature of—

30°	is saturated with	2	grains of	vapour of water.
49	„	4	„	„
79	„	8	„	„
92¼	„	16	„	„

The capacity of air for moisture therefore doubles for every increase of temperature of about 20 degrees.

The temperature of the dew-point is the temperature to which air must be reduced in order to become saturated by the water then mixed with it; or it is that temperature to which any substance, such as the bright bulb of a hygrometer, must be reduced before any of the aqueous vapour present will be deposited as water, and become visible as dew. The temperature at which this first bedewing or dulling of bright surfaces takes place is the temperature of the dew-point. For instance, I have already said that two grains of water saturate a cubic foot of air at 30°: if, therefore, the temperature of the air be 40°, and there be two grains of moisture in a cubic foot of air, then, if the bulb of the hygrometer be reduced to 30°, a ring of dew will appear on it, caused by the deposition of the water in the air.

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The determination of the dew-point at once tells us therefore the amount of water present, and, combined with the temperature, enables us to determine the hygrometrical state of the atmosphere.

If the air be saturated with moisture, the temperature of the air and that of the dew-point are alike; if it be not saturated, the temperature of the dew-point is lower than that of the atmosphere; if there be a great difference between the two temperatures, the air is dry; and if this happen when the temperature is low, there is very little water present in the air.

By the careful simultaneous readings of two thermometers, one with a moistened bulb and the other dry, or by the use of a Daniell's or Regnault's hygrometer, the amount of water present in the air in the invisible shape of vapour can be determined, as well as the temperature of the dew-point and the degree of humidity.

The degree of humidity of the air expresses the ratio between the amount of water then mixed with it and the greatest amount it could hold in solution at its then temperature, upon the supposition that the saturated air is represented by 100, and air deprived of all moisture by 0. Thus: Suppose the water present to be one-half of the quantity that could be present, the degree of humidity in this case will be 50. If the air were at the temperature of 30°, and there were two grains of moisture in the air, it would be saturated, and the degree of humidity would be 100. If there were one grain, that is one-half of the whole quantity that could be present, the air would be one-half saturated, and the degree of humidity would be represented by 50.

At 49° with 4 grains of moisture „ 70 „ 8 „ „ 92½ „ 16 „	}	The air is saturated, and the degree of humidity is 100.
But at 49° with 2 grains of moisture „ 70 „ 4 „ „ 92½ „ 8 „	}	The air is one-half saturated, and the degree of humidity is 50.

The thermometers employed in the observations were exceedingly sensitive; the bulbs, long and cylindrical, being almost three-tenths of an inch in length. The graduations, which extended to minus 40°, were all made on ivory scales. These thermometers, on being removed from a room heated 20° above that of the surrounding air, acquired the temperature within half a degree in about ten or twelve seconds. They were so sensitive that no correction was necessary for sluggishness; and this was proved to be the case by the near agreement of the readings at the same height in the ascending and descending curves, in cases when there was no reason to suppose there had been any change of temperature at the same height within the interval between the two series of observations.

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I had two pairs of dry and wet bulb thermometers; one pair similar to those ordinarily used, the bulbs being protected from the direct rays of the sun by a highly polished silver shade, in the form of a frustrum of a cone, open at top and bottom, and a cistern fixed near to them for the supply of water to the wet-bulb thermometer, as shown in the diagram.

The second pair were arranged for the employment of the aspirator, the object of which was to induce at will a current of air across the bulbs, which, being highly sensitive, would almost instantaneously record the temperature of the air so set in motion. In this arrangement the thermometers were enclosed in silver tubes placed side by side, connected together at top by a cross tube, and both protected by a shade, as in ordinary use. In the left-hand tube belonging to the dry-bulb an opening was provided. By means of the aspirator a current of air was drawn in at this opening, which, traversing round the tubes, passed away into the aspirator. Thus the temperature of the air in motion against the bulbs could be determined at pleasure with the utmost nicety. (See diagram.)

Regnault's condensing hygrometer was made with two thermometers, and as described by Regnault himself. The scales were made of ivory, and the thermometers fitted to the cups with cork, ready for packing up at short notice.

The reader may judge from the diagram the arrangement of some of the instruments.

At the extreme left (No. 1) are seen the dry and wet bulb thermometers.

No. 2 is Daniell's hygrometer.

No. 3, the mercurial barometer.

No. 4, a blackened bulb thermometer, with its bulb fully exposed to the sun's rays.

No. 5, two thermometers, dry and wet bulb, in connection with the aspirator.

No. 6, a blackened bulb thermometer, placed in an hermetically sealed vacuum tube, projecting outwards, as in No. 4, so that the bulb was in the full rays of the sun.

No. 7, an aneroid barometer.

No. 8, an excessively delicate thermometer, with its bulb in form of a gridiron. This arrangement was adopted for the purpose of increasing the sensibility of the instrument.

No. 9, Regnault's hygrometer, with its india-rubber tube in connection with the aspirator.

No. 10, one of two silver conical shields, the one within the other, with a space between, for protecting the dry thermometer from the

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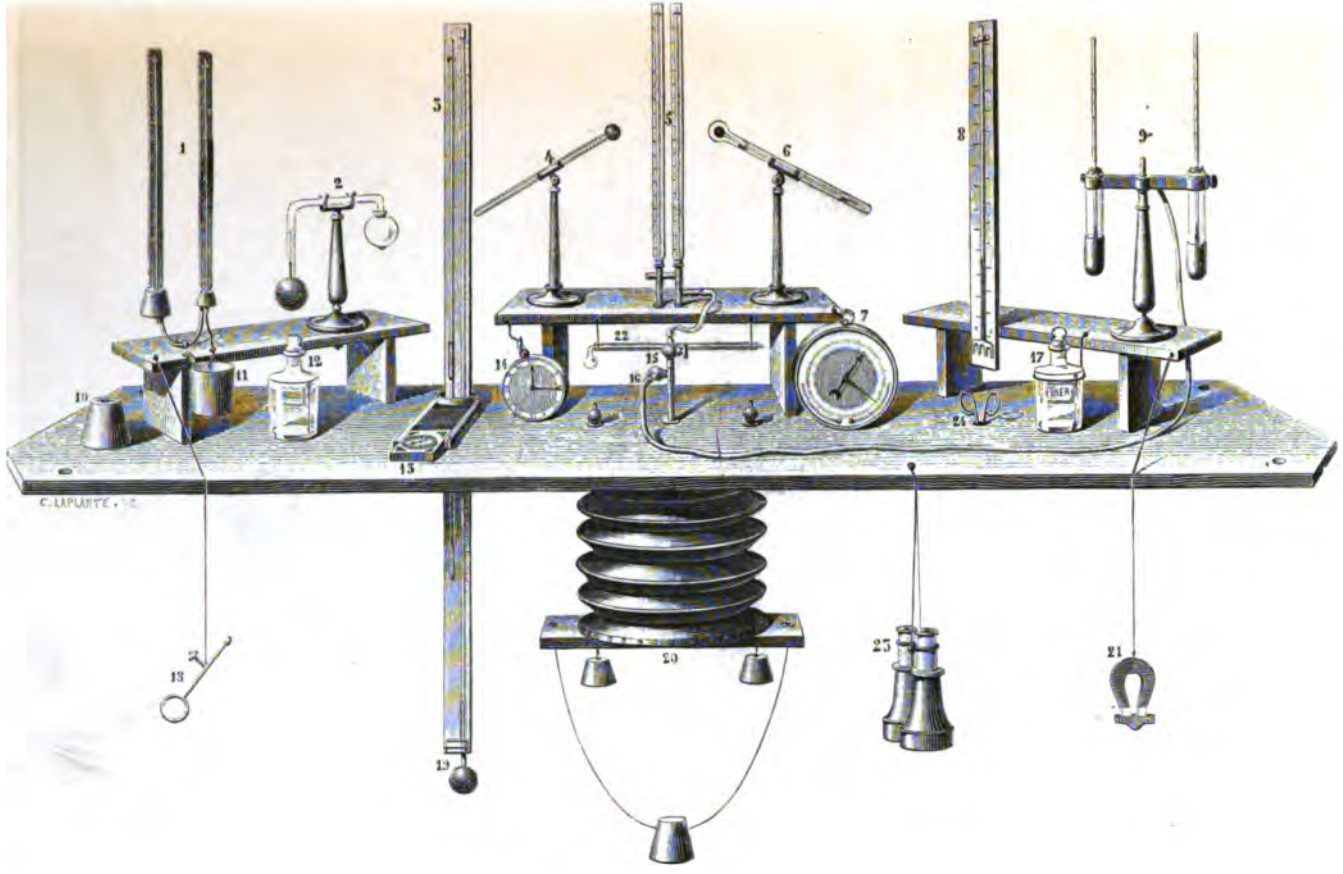

THE INSTRUMENTS OF MR. GLAISHER ARRANGED IN THE CAR.

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sun's rays. These rested on a silver shoulder affixed to the thermometer tube, just above the bulb of each thermometer. The wet thermometer was protected in a similar way. The shields are removed from their proper places in the drawing to show the means adopted to supply water to the bulb by means of capillarity.

No. 11, the water-vessel for the wet-bulb thermometer.

No. 12, a small bottle of water.

No. 13, a compass.

No. 14, a watch or chronometer.

Nos. 15 and 16, two taps connected with the aspirator, the one connected with the dry and wet bulb thermometers (5), and the other with Regnault's hygrometer (9).

No. 17, a bottle of ether, for use with Daniell's and Regnault's hygrometers.

No. 18, a lens to read the instruments.

No. 19, a weight attached to the barometer to keep it vertical.

No. 20, the aspirator arranged to be worked by the foot.

No. 21, a magnet, for the purpose of giving vibrations to the compass needle.

No. 22, a minimum thermometer.

No. 23, an opera glass.

No. 24, a pair of scissors for cutting the strings.

All the instruments were attached to the table with strings, which could be cut immediately, or they merely rested on stands which were screwed to the table. This table was fixed across the car, and tied there by strong cord. On approaching the earth, all the instruments were rapidly removed and placed, anyhow, in a basket, furnished with a number of soft cushions to cover them in layers, so that they were not broken by the shock on coming in contact with the earth. When more than two or three persons were in the car, besides myself, the arrangement of the instruments was different, and they were less in number.

As such ascents (when several were in the car) of necessity could not be of extreme heights, and as it was found in the high ascents that the aneroid read at all times very nearly the same as the mercurial barometer, the same aneroid which had thus been tested was alone used for the determination of elevation, and the mercurial barometer was therefore not taken up.

It had also always been found that the dry and wet bulb thermometers, whether aspirated or not, read alike; the use of those under the influence of the aspirator was therefore dispensed with; and as in point of fact one thermometer and one bright surface are all that

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Regnault's hygrometer needs to determine the temperature of the deposit of dew, one of the thermometers only was used.

By these alterations I was enabled to conveniently place all the necessary instruments in a much smaller space; and ultimately, in my low ascents, I managed to place them all on a board, projecting beyond the side of the car, which had the double advantage of allowing the air to play more freely about them, and leaving the aëronaut more room. There was also a third arrangement adopted, viz. that for night ascents. The inconvenience of reading instruments at night necessitates the use of even a smaller number. In such experiments I have usually confined myself to the determination of the temperature and humidity of the air at different elevations by the use of the dry and wet thermometers solely.

In the night ascents I took with me a well-made Davy safety-lamp, having previously tested it by plunging it into lighted gas proceeding from a pipe. I also took the lamp up on a day ascent, and found it could be used in a balloon-car with perfect ease. By its use I was therefore able to read the instruments at night, though less quickly than in daylight. I used the same framework, placed outside the car as before, so that I stood with my back towards the aëronaut to whom the management of the balloon was entrusted. At night I also used to place a padded cushion, fitted into the frame, with padded sides, and in this I placed the watch, barometer, pencils, &c.

I have been thus particular in describing my arrangements, as they are the result of much thought and care, based upon experience.

At times I have taken up other instruments, such as the spectroscope, ozone tests, an actinometer, &c.; and this I was enabled to do when I found I could dispense with all the aspirating apparatus and some of the other instruments which were thought to be necessary at first: these I do not think I need particularize. The great principle to be attended to in the arrangement of the table is to fix everything by nuts, screws, or strings, and to place the instruments in such positions that they can be read with rapidity and ease, and removed in a very short time into a wadded case, so that they are not broken by the concussion.

On the 30th of June, 1862, Mr. Coxwell brought his new balloon to Wolverhampton; it was not made of silk, but of American cloth, a material possessed of a great strength. Its capacity was 90,000 cubic feet, exceeding in size that of the famous *Nassau* balloon. Misfortune again followed the attempts of the committee; for, notwithstanding frequent uncomfortable gusts of wind, the inflation of the balloon was proceeded with, and after three hours about 60,000 feet of gas had

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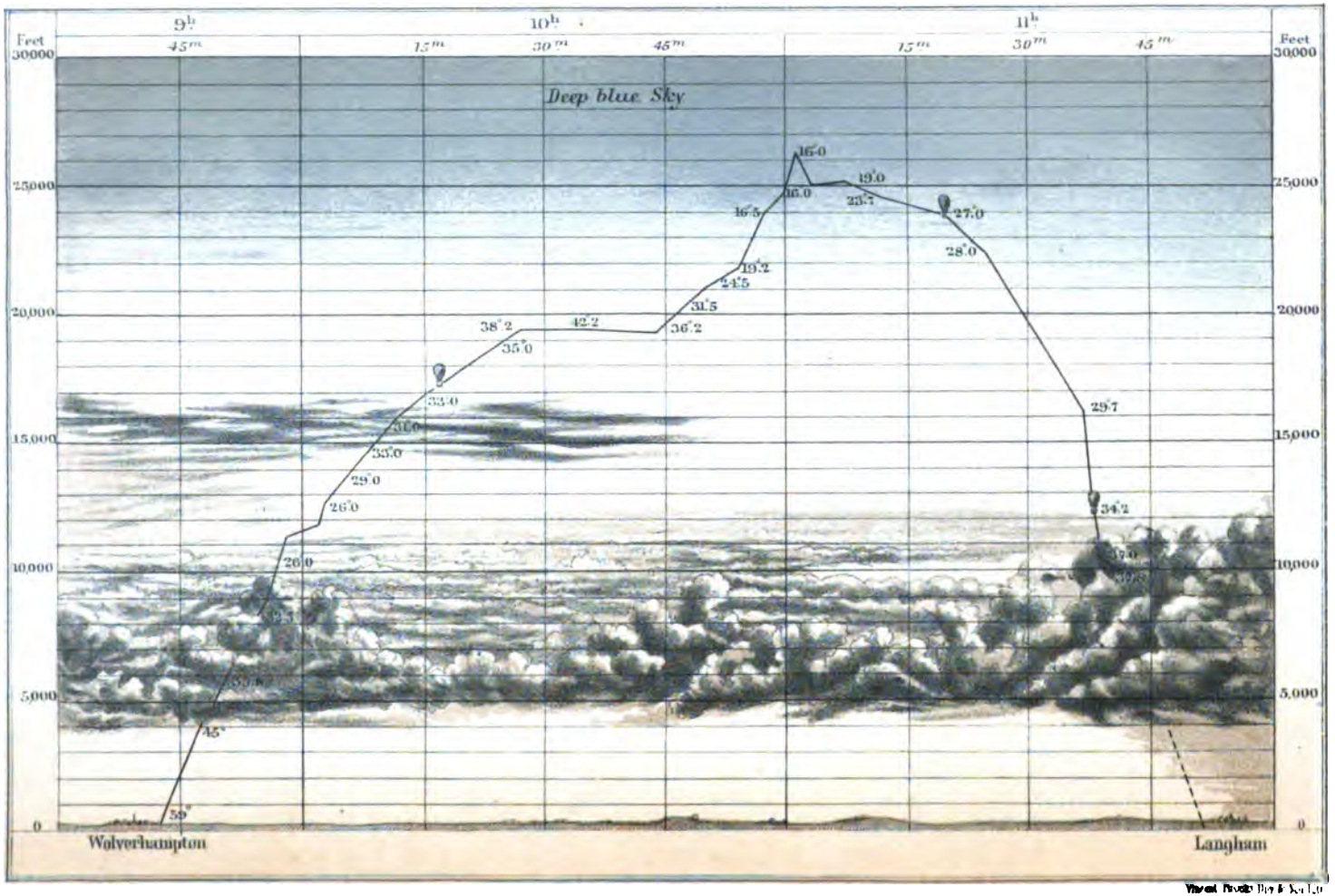

Path of the Balloon in its ascent from Wolverhampton to Langham.
July 17th 1862

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passed in. At this time the wind arose, and great apprehensions were felt for the safety of the balloon, so that the supply of gas had to be cut off. The fierceness of the wind increased, and the balloon split upwards to the first cross seam, and taking the course of the seam, the rent ran almost round the balloon at its widest part. So much injury was done that it took more than a week to repair it, although many persons were employed on the work.

The directors of the Gas Company, and their engineer, Mr. Proud, very kindly consented to make, and to store away, some light gas, which we could not otherwise have procured. It is known that the products of the distillation of coal in a closed retort are richest in illuminating power at the commencement of the operation, and that their value diminishes as the distillation proceeds. The products of the last distillation are composed of a light gas, of weak illuminating power, but most suitable for balloon ascents. These last products were put into a special gasometer, and it is due to this circumstance that I was enabled to make the extreme high ascents, which would have been quite impossible if the Company had not placed a gasometer at our disposal.

After the balloon was repaired, a week's bad weather followed, and July 17 was the last day my engagements permitted me to remain at Wolverhampton. The filling of the balloon began at five o'clock in the morning, in the presence of Lord Wrottesley. As it proceeded, the weather increased in badness; and if it had not been for the already great loss of time and the continued postponement of the ascent that would have otherwise taken place, we should not have set at defiance the terrible W.S.W. wind, which was blowing without interruption. Very great difficulties were experienced in the inflation, and it seemed as if the operation would never be completed. The movements of the balloon were so great and so rapid, that it was impossible to fix a single instrument in its position before quitting the earth, and the state of affairs was by no means cheering to a novice who had never before put his foot in the car of a balloon. When Mr. Coxwell made up his mind, at 9h. 42m., to let go, the balloon, which had been so impatient to be free, did not rise, but moved horizontally on the ground for some distance, dragging the car on its side; which movement would have been fatal had there been any chimney or lofty buildings in the way.

We left the earth at about 9h. 43m. A.M., and at 9h. 49m. reached the clouds at an elevation of 4,467 feet. Rising still higher, at 9h. 51m., with an elevation of 5,802 feet, we passed out of this stratum of cloud, but again became enveloped in a cumulo-stratus

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at the height of 7,980 feet. The sun shone brightly upon us at 9h. 55m., and caused the gas to expand and the balloon itself to assume the shape of a perfect globe. A most magnificent view now presented itself, but, unfortunately, I was not able to devote any time to note its peculiarities and its beauty, as I was still arranging my instruments in the positions they were to occupy, and we had reached a height exceeding 10,000 feet before all the instruments were in working order. The clouds at this time (10h. 2m.) were very beautiful, and at 10h. 3m., at an elevation of 12,709 feet, a band of music was heard. At 10h. 4m. the earth became visible through breaks in the clouds. At 16,914 feet the clouds were far below us, both cumulus and stratus, however, at a distance appearing to be at the same height as ourselves, the sky above us being perfectly cloudless and of an intense prussian blue.

At starting, the temperature of the air was 59°, and the dew-point 55°; at 4,000 feet it was 45°, dew-point 33°, and it descended to 26° at 10,000 feet, dew-point 19°; and then there was no variation of temperature between this height and 13,000 feet. During the time of passing through this space an addition was made to our clothing, as we felt certain we should experience a temperature below zero before we reached the height of five miles; but, to my surprise, at the height of 15,500 feet, the temperature as shown by all the sensitive instruments was 31°, with a dew-point of 25°, and at each successive reading up to 19,500 feet the temperature increased, and was 42° at this height, with dew-point at 24°. We had both thrown off all extra clothing. Within two minutes after this time, when we had fallen somewhat, the temperature again began to decrease with extraordinary rapidity to 16°, or 27° less than it was twenty-six minutes previously.

At the height of 18,844 feet, eighteen vibrations of a horizontal magnet occupied 26·8ˢ, and at the same height my pulse beat at the rate of 100 pulsations per minute. At 19,415 feet palpitation of the heart became perceptible, the beating of the chronometer seemed very loud, and my breathing became affected. At 19,435 feet my pulse had accelerated, and it was with increasing difficulty that I could read the instruments; the palpitation of the heart was very perceptible. The hands and lips assumed a dark bluish colour, but not the face. At 20,238 feet, twenty-eight vibrations of a horizontal magnet occupied 43ˢ. At 21,792 feet I experienced a feeling analogous to sea-sickness, though there was neither pitching nor rolling in the balloon; and through this illness I was unable to watch the instruments long enough to lower the temperature to get a deposit of dew. The sky at this elevation was of a very deep blue colour, and the clouds were

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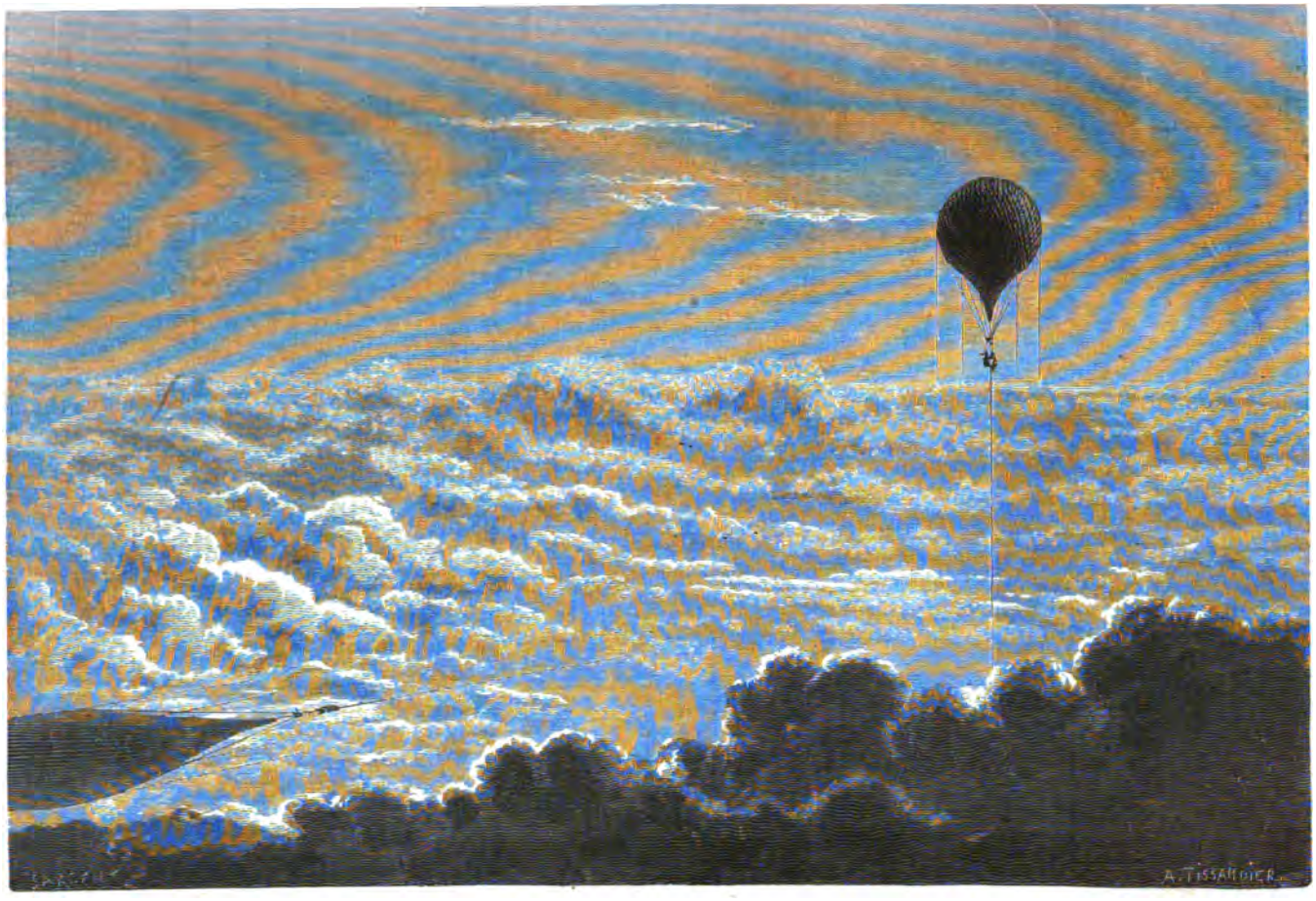

SHADOW OF THE BALLOON ON THE CLOUDS.

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far below us. At 22,357 feet I endeavoured to make the magnet vibrate, but could not; it moved through arcs of about 20°, and then settled suddenly.

Our descent began a little after 11 A.M., Mr. Coxwell experiencing considerable uneasiness at our too close vicinity to the Wash. We came down quickly, passing from a height of 16,300 feet to one of 12,400 feet between 11h. 37m. and 11h. 38m.; at this elevation we entered into a dense cloud which proved to be no less than 8,000 feet in thickness, and whilst passing through this the balloon was invisible from the car. From the rapidity of the descent the balloon assumed the shape of a parachute; and though Mr. Coxwell had reserved a large amount of ballast, which he discharged as quickly as possible, we collected so much weight by the condensation of the immense amount of vapour through which we passed, that notwithstanding all his exertions we came to the earth with a very considerable shock, which broke nearly all the instruments. All the sand was discharged when we were at a considerable elevation. The amount we had at our disposal at the height of five miles was fully 500 lbs.; this seemed to be more than ample, and, when compared with that retained by Gay-Lussac, viz. 33 lbs., and by Rush and Green, when the barometer reading was eleven inches, viz. 70 lbs., seemed indeed to be more than we could possibly need; yet it proved to be insufficient.

The descent took place at Langham, near Oakham, in Rutlandshire.

ABOVE THE CLOUDS.

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"WE PASSED THROUGH A MAGNIFICENT CUMULUS CLOUD."

CHAPTER III.

ASCENTS FROM WOLVERHAMPTON.

AUGUST 18, 1862.

THE weather on this day was favourable; there was but little wind from the N.E. By noon the balloon was nearly inflated. As it merely swayed in the light wind, the instruments were fixed before starting, and at 1h. 2m. 38s. the spring-catch was pulled, when for a moment the balloon remained motionless, and then rose slowly and steadily. In about ten minutes we passed into a magnificent cumulus cloud, and emerged from it into a clear space, with a beautiful deep blue sky, dotted with cirri, leaving beneath us an exceedingly beautiful mass of cumulus clouds, displaying a variety of magnificent lights and shades. Our direction was towards Birmingham, which came into view about 1h. 15m.

When at the height of nearly 12,000 feet, with the temperature at 38°, or 30° less than on the ground, and the dew-point at 26°, the valve was opened, and we descended to a little above 3,000 feet. The view became most glorious; very fine cumulus clouds were situated far below, and plains of clouds were visible to a great distance. Wolverhampton, beneath us, was sharply and well defined, appearing like a model. The clouds during this ascent were remarkable for their supreme beauty, presenting at times mountain

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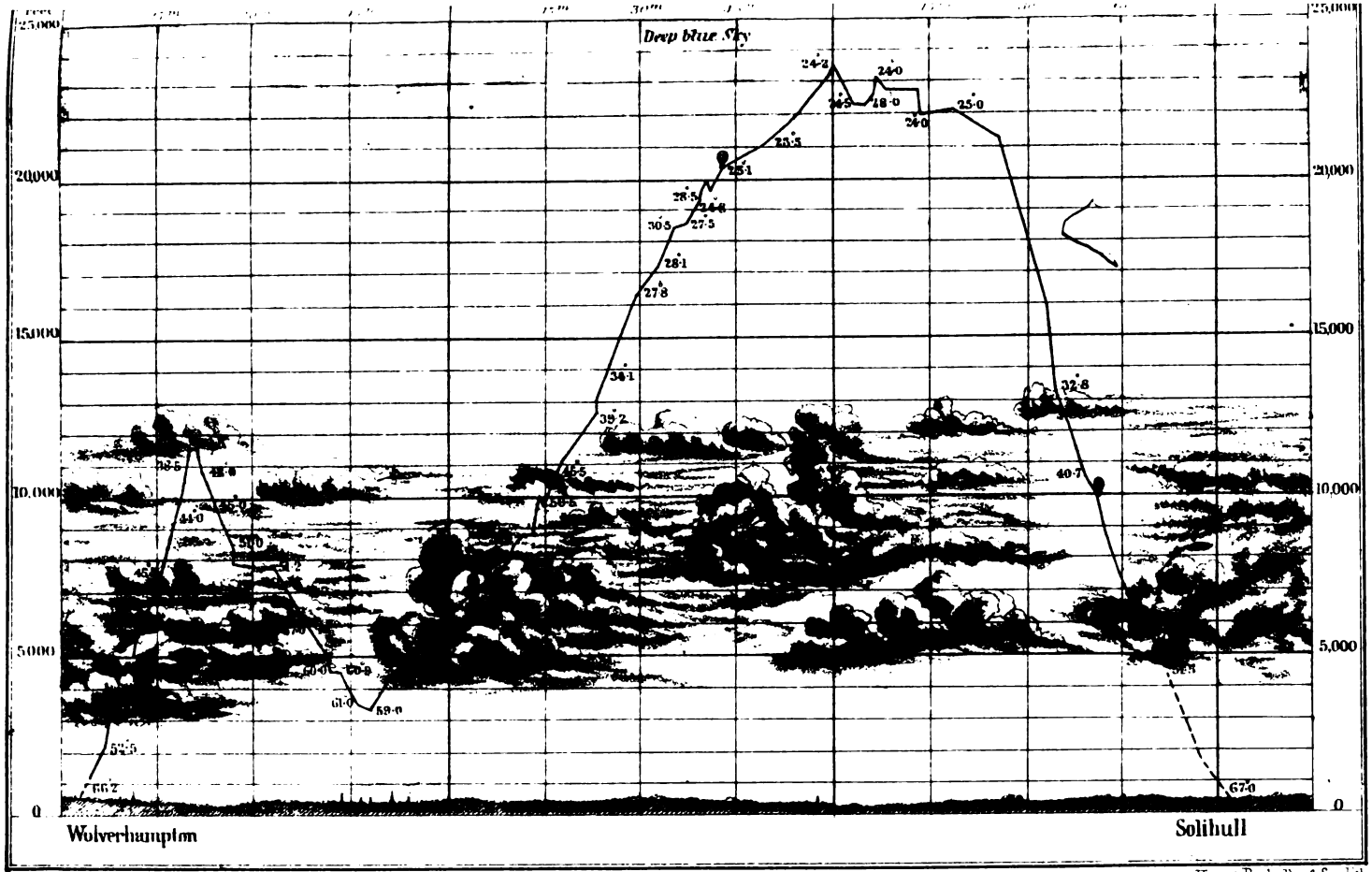

Path of the Balloon in its ascent from Wolverhampton to Solihull.
18th August 1862.

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scenes of endless variety and grandeur, and fine dome-like clouds dazzled and charmed the eye with alternations and brilliant effects of light and shade. The air on descending felt warm.

We were about midway between Wolverhampton and a town (Walsall) when the balloon slightly collapsed, causing it to descend a little, and the shouting of people was plainly heard, who expected the balloon would descend (see diagram). At 1h. 48m. sand was discharged, and a very gradual ascent took place, the direction being along the high-road to Birmingham. On looking over the side of the car the shadow of the balloon on the clouds was observed to be surrounded by a kind of corona tinted by prismatic colours, and the rippling of the water on the edges of the canal could be seen very distinctly. We discharged sand several times to enable us to rise. The view continued very grand; a great mass of clouds was observed in the east, and a large town lay on our right. The balloon was again full. At 2h. 34m. 20s. and at 2h. 45m. thunder was heard from below, but no cloud could be seen. At 2h. 54m. my pulsations were 100, 107, and 110 successively in one minute. When at the height of 24,000 feet, at 2h. 59m., a consultation took place as to the prudence of discharging more ballast, or retaining it so as to ensure a safe descent; ultimately it was decided not to ascend, as some clouds whose thickness we could not tell had to be passed through. At 3h. 3m. it was difficult to obtain a deposit of dew on the hygrometer, and the working of the aspirator became troublesome. A sound like loud thunder was again heard at 3h. 13m.; at 3h. 25m. I began to feel unwell. About 3h. 26m. a most remarkable view presented itself: the sky was of a fine deep blue, dotted with cirri. The earth and its fields, where visible, appeared very beautiful indeed—here, hidden by vast cumuli and plains or seas of cumulo-strata, causing the country beneath to be shaded for many hundreds of square miles; there, without a cloud to obscure the sun's rays. Again, in other places there were detached cumuli, whose surfaces appeared connected by vast plains of hillocky clouds, and in the interstices the earth was visible, but partly obscured by blue haze or mist. In another place brightly shining cumuli were observed, and seas of detached clouds which cannot be described. Due north, a beautiful cloud, the same we passed through on leaving Wolverhampton, and which had followed us on our way, still reigned in splendour, and might from its grandeur have been called the monarch of clouds. On looking over the top of the car the horizon appeared to be on a level with the eye; the image of the balloon and car, in descending, was very distinctly visible on the clouds. We entered clouds at 3h. 45m. and lost sight of the sun,

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but broke through at 3h. 50m. and saw the earth. Preparations were made for the descent, which, after we had passed through some mist, took place at Solihull, about seven miles from Birmingham.

SEPTEMBER 5, 1862.

This ascent had been delayed owing to the unfavourable state of the weather. We left the earth at 1h. 3m. P.M.; the temperature of the air was 59°, and that of the dew-point 50°. The air at first was misty; at the height of 5,000 feet the temperature was 41°, dew-point 37°·9. At 1h. 13m. we entered a dense cloud of about 1,100 feet in thickness, where the temperature fell to 36°·5, the dew-point being the same, thus indicating that the air here was saturated with moisture. At this elevation the report of a gun was heard. Momentarily the clouds became lighter, and on emerging from them at 1h. 17m. a flood of strong sunlight burst upon us with a beautiful blue sky without a cloud, and beneath us lay a magnificent sea of clouds, its surface varied with endless hills, hillocks, and mountain chains, and with many snow-white tufts rising from it. I here attempted to take a view with the camera, but we were rising with too great rapidity and revolving too quickly to enable me to succeed. The brightness of the clouds, however, was so great that I should have needed but a momentary exposure, Dr. Hill Norris having kindly furnished me with extremely sensitive dry plates for the purpose. We reached the height of two miles at 1h. 22m., where the sky was of a darker blue, and from whence the earth was visible in occasional patches beneath the clouds. The temperature had fallen to the freezing-point, and the dew-point to 26°. The height of three miles was attained at 1h. 28m., with a temperature of 18°, and dew-point 13°; from 1h. 22m. to 1h. 30m. the wet-bulb thermometer read incorrectly, the ice not being properly formed on it. At 1h. 34m. Mr. Coxwell was panting for breath; at 1h. 38m. the mercury of Daniell's hygrometer fell below the limits of the scale. We reached the elevation of four miles at 1h. 40m.; the temperature was 8°, the dew-point minus 15°, or 47° below the freezing-point of water. Discharging sand, we in ten minutes attained the altitude of five miles, and the temperature had passed below zero and then read minus 2°·0. At this point no dew was observed on Regnault's hygrometer when cooled down to minus 30°. Up to this time I had taken observations with comfort, and experienced no difficulty in breathing, whilst Mr. Coxwell, in consequence of the exertions he had to make, had breathed with difficulty for some time. Having discharged sand,

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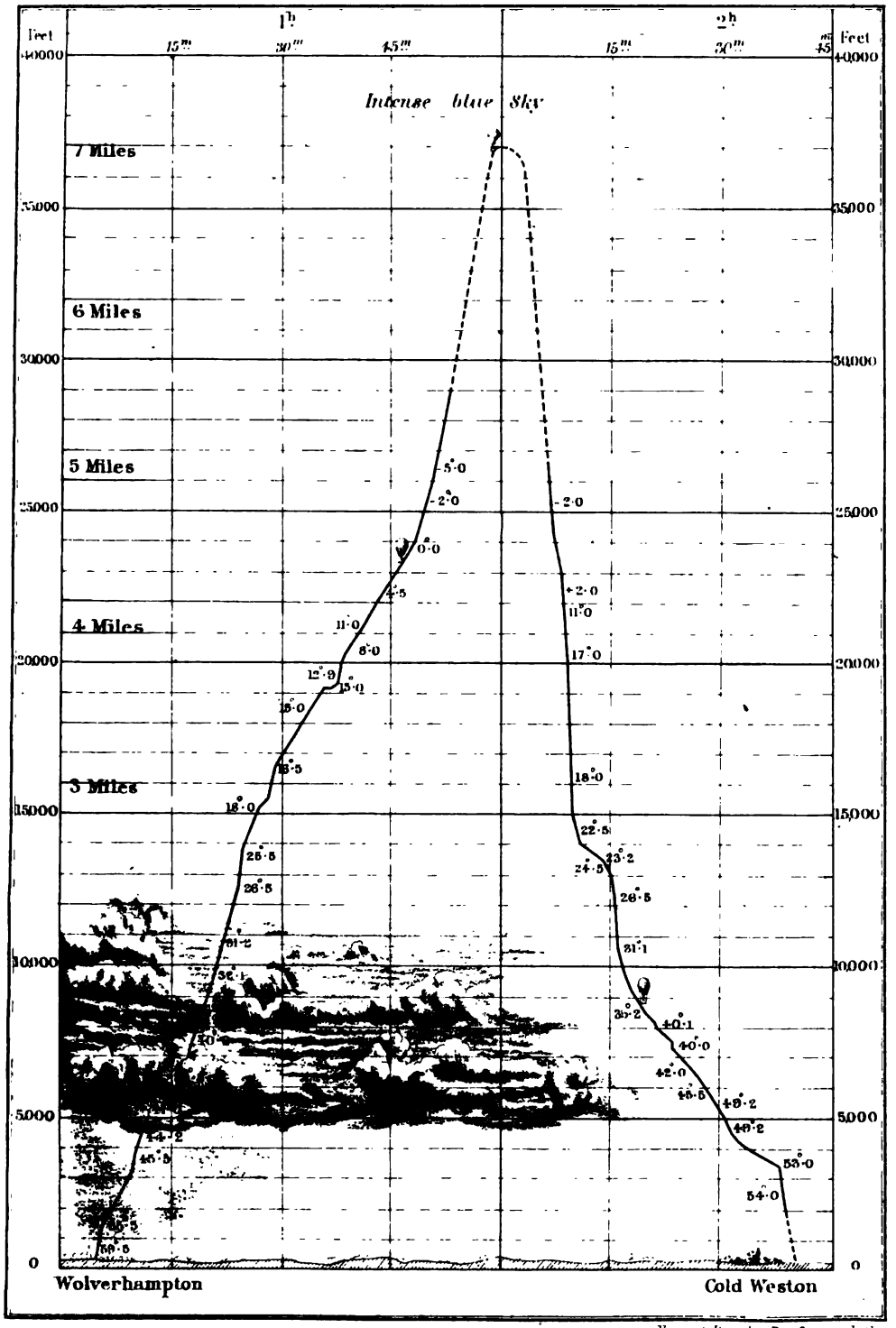

Vincent Brooks, Day & Son. Lith.

Path of the Balloon in its ascent from Wolverhampton to Cold Weston near Ludlow.

5th September 1862.

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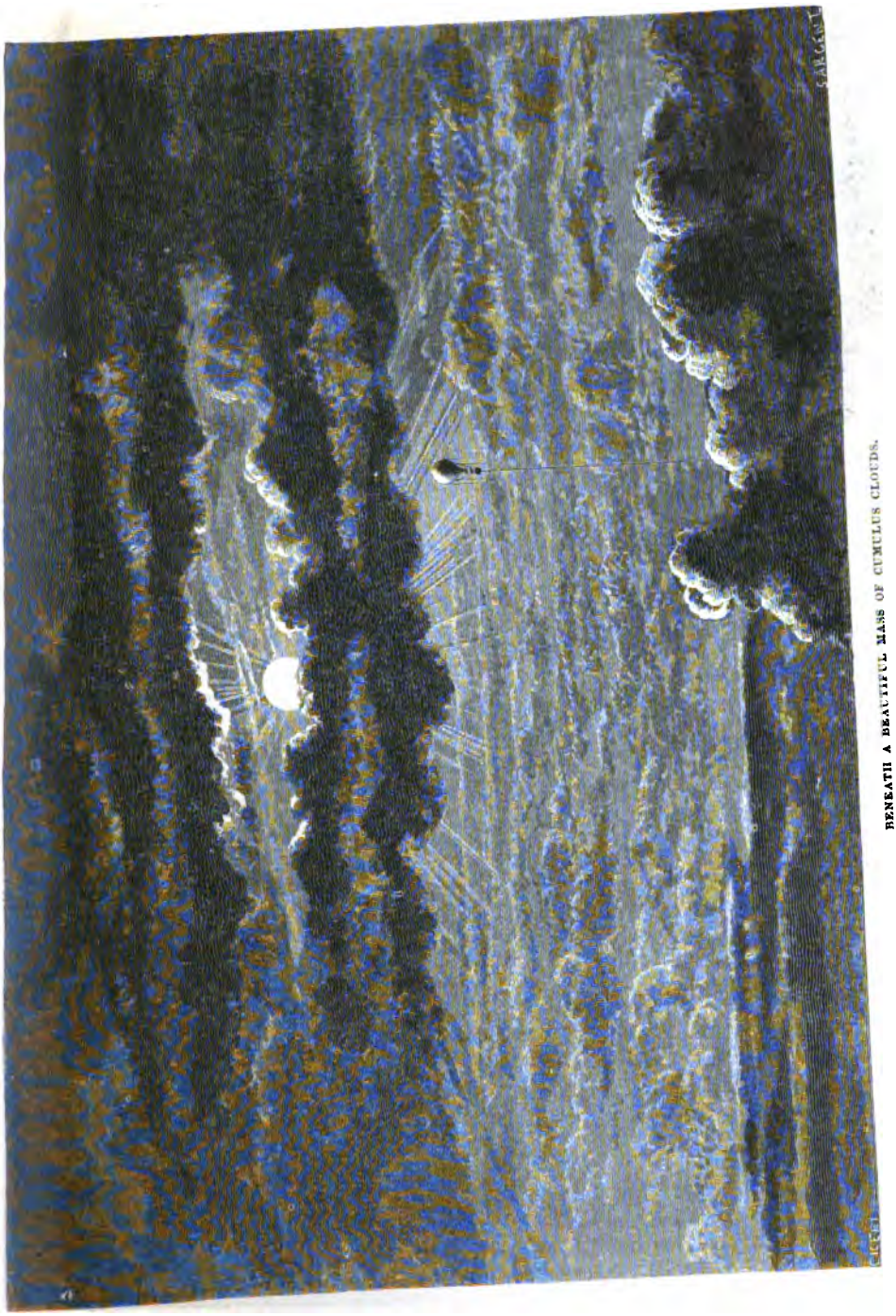

BENEATH A BEAUTIFUL MASS OF CUMULUS CLOUDS.

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we ascended still higher; the aspirator became troublesome to work; and I also found a difficulty in seeing clearly. At 1h. 51m. the barometer read 10·8in. About 1h. 52m. or later, I read the dry-bulb thermometer as minus 5°; after this I could not see the column of mercury in the wet-bulb thermometer, nor the hands of the watch, nor the fine divisions on any instrument. I asked Mr. Coxwell to help me to read the instruments. In consequence, however, of the rotatory motion of the balloon, which had continued without ceasing since leaving the earth, the valve-line had become entangled, and he had to leave the car and mount into the ring to readjust it. I then looked at the barometer, and found its reading to be 9¾in., still decreasing fast, implying a height exceeding 29,000 feet. Shortly after I laid my arm upon the table, possessed of its full vigour, but on being desirous of using it I found it powerless—it must have lost its power momentarily; trying to move the other arm, I found it powerless also. Then I tried to shake myself, and succeeded, but I seemed to have no limbs. In looking at the barometer my head fell over my left shoulder; I struggled and shook my body again, but could not move my arms. Getting my head upright for an instant only, it fell on my right shoulder; then I fell backwards, my back resting against the side of the car and my head on its edge. In this position my eyes were directed to Mr. Coxwell in the ring. When I shook my body I seemed to have full power over the muscles of the back, and considerably so over those of the neck, but none over either my arms or my legs. As in the case of the arms, so all muscular power was lost in an instant from my back and neck. I dimly saw Mr. Coxwell, and endeavoured to speak, but could not. In an instant intense darkness overcame me, so that the optic nerve lost power suddenly, but I was still conscious, with as active a brain as at the present moment whilst writing this. I thought I had been seized with asphyxia, and believed I should experience nothing more, as death would come unless we speedily descended: other thoughts were entering my mind, when I suddenly became unconscious as on going to sleep. I cannot tell anything of the sense of hearing, as no sound reaches the air to break the perfect stillness and silence of the regions between six and seven miles above the earth. My last observation was made at 1h. 54m. above 29,000 feet. I suppose two or three minutes to have elapsed between my eyes becoming insensible to seeing fine divisions and 1h. 54m., and then two or three minutes more to have passed till I was insensible, which I think, therefore, took place about 1h. 56m. or 57m.

Whilst powerless I heard the words "temperature" and "observa-

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tion," and I knew Mr. Coxwell was in the car, speaking to and endeavouring to rouse me,—therefore consciousness and hearing had returned. I then heard him speak more emphatically, but could not see, speak, or move. I heard him again say, "Do try; now do." Then the instruments became dimly visible, then Mr. Coxwell, and very shortly I saw clearly. Next I arose in my seat and looked around as though waking from sleep, though not refreshed, and said to Mr. Coxwell, "I have been insensible." He said, "You have, and I too, very nearly." I then drew up my legs, which had been extended, and took a pencil in my hand to begin observations. Mr. Coxwell told me that he had lost the use of his hands, which were black, and I poured brandy over them.

I resumed my observations at 2h. 7m., recording the barometer reading at 11·53 inches, and temperature minus 2°. It is probable that three or four minutes passed from the time of my hearing the words "temperature" and "observation," till I began to observe; if so, returning consciousness came at 2h. 4m. P.M., and this gives seven minutes for total insensibility. I found the water in the vessel supplying the wet-bulb thermometer one solid mass of ice, though I had, by frequent disturbance, kept it from freezing. It did not all melt until we had been on the ground some time. Mr. Coxwell told me that while in the ring he felt it piercingly cold; that hoarfrost was all round the neck of the balloon, and that on attempting to leave the ring he found his hands frozen. He had, therefore, to place his arms on the ring, and drop down. When he saw me he thought for a moment that I had lain back to rest myself, and he spoke to me without eliciting a reply; he then noticed that my legs projected and my arms hung down by my side, and saw that my countenance was serene and placid, without the earnestness and anxiety he had observed before going into the ring: then it struck him that I was insensible. He wished to approach me, but could not; and when he felt insensibility coming over him too, he became anxious to open the valve. But in consequence of having lost the use of his hands he could not do this; ultimately he succeeded, by seizing the cord with his teeth, and dipping his head two or three times, until the balloon took a decided turn downward.

No inconvenience followed my insensibility; and when we stopped it was in a country where no conveyance of any kind could be obtained, so I had to walk between seven and eight miles.

During the descent, which was at first very rapid, the wind was easterly. To check the rapidity of the descent, sand was thrown out at 2h. 30m. The wet bulb seemed to be free from ice at this time,

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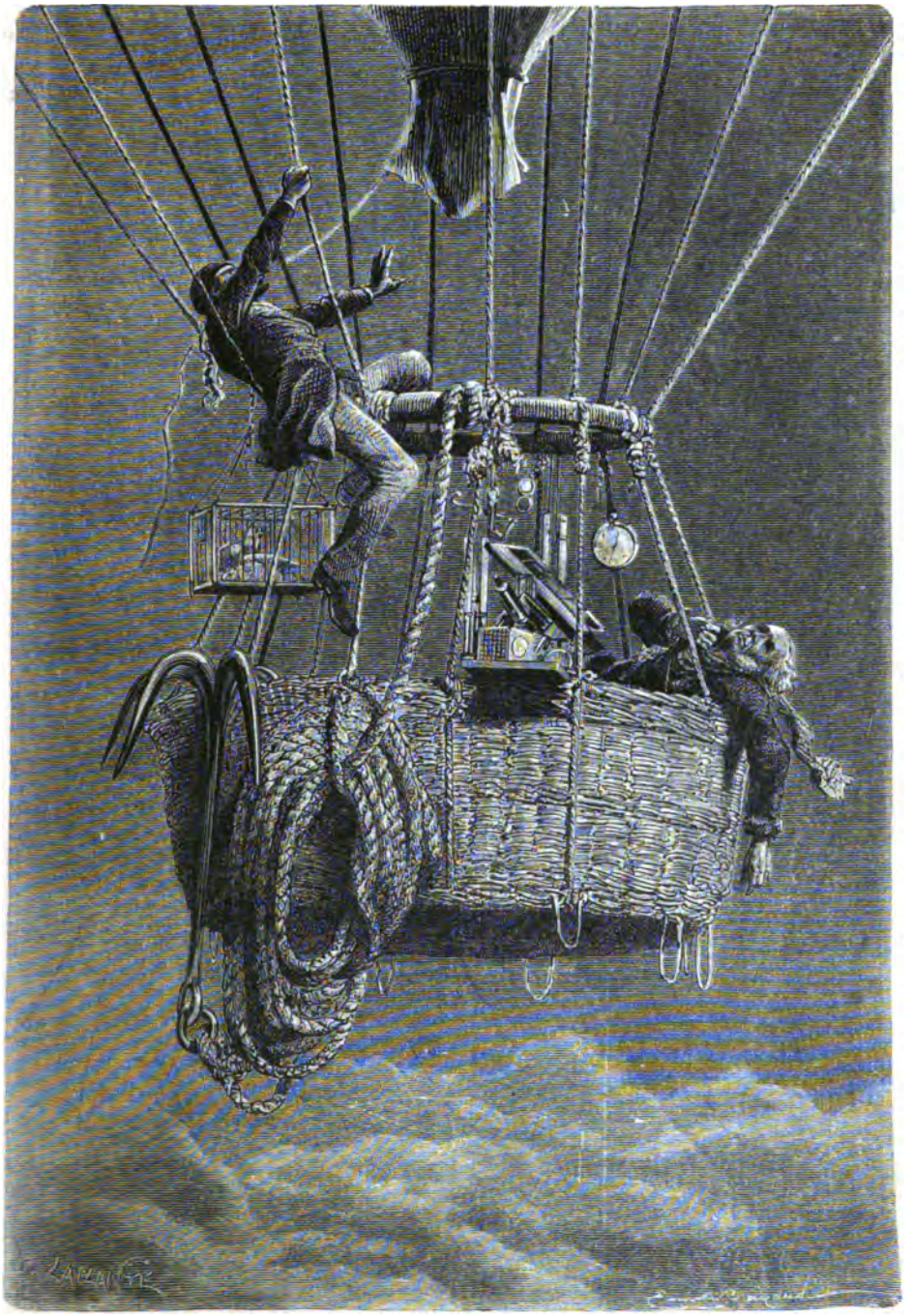

MR. GLAISHER INSENSIBLE AT THE HEIGHT OF SEVEN MILES

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but I held the bulb between my thumb and finger, for the purpose of melting any ice remaining on it or the connecting thread. The readings after this appeared correct. The final descent took place in the centre of a large grass-field belonging to Mr. Kersall, at Cold Weston, seven miles and a half from Ludlow.

I have already said that my last observation was made at a height of 29,000 feet; at this time (1h. 54m.) we were ascending at the rate of 1,000 feet per minute; and when I resumed observations we were descending at the rate of 2,000 feet per minute. These two positions must be connected, taking into account the interval of time between, viz. 13 minutes. And on these considerations, the balloon must have attained the altitude of 36,000 or 37,000 feet. Again, a very delicate minimum thermometer read minus 11°·9, and this would give a height of 37,000 feet. Mr. Coxwell, on coming from the ring, noticed that the centre of the aneroid barometer, its blue hand, and a rope attached to the car, were all in the same straight line, and this gave a reading of 7 inches, and leads to the same result. Therefore, these independent means all lead to about the same elevation, viz. fully seven miles.

In this ascent six pigeons were taken up. One was thrown out at the height of three miles, when it extended its wings and dropped like a piece of paper; the second, at four miles, flew vigorously round and round, apparently taking a dip each time; a third was thrown out between four and five miles, and it fell downwards as a stone. A fourth was thrown out at four miles on descending; it flew in a circle, and shortly alighted on the top of the balloon. The two remaining pigeons were brought down to the ground. One was found to be dead; and the other, a carrier, was still living, but would not leave the hand when I attempted to throw it off, till, after a quarter of an hour, it began to peck at a piece of ribbon with which its neck was encircled; it was then jerked off the finger, and shortly afterwards flew with some vigour towards Wolverhampton. One of the pigeons returned to Wolverhampton on Sunday the 7th, and it was the only one I ever heard of.

In this ascent, on passing out of the clouds there was an increase of 9°, and then there was no interruption in the decrease of temperature till the height of 15,000 feet was reached, when a warm current of air was entered, which continued to 24,000 feet, after which the regular decrease of temperature continued to the highest point reached. On descending, the same current was again met with, between 22,000 and 23,000 feet. A similar interruption, but to a greater amount, was experienced till the balloon had descended to about the same height in which it was reached on ascending; after

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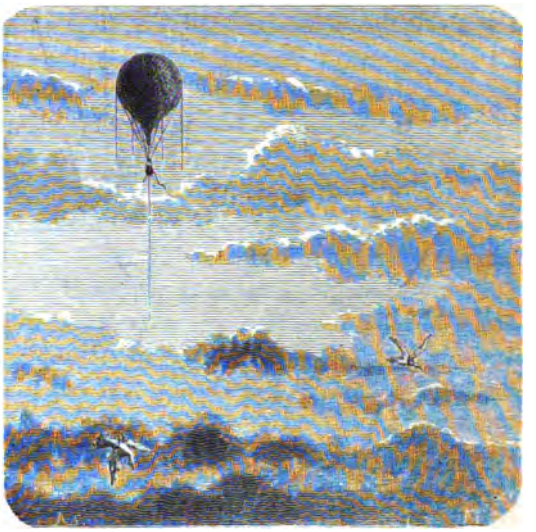
this no further break occurred in the regular increase of temperature, the sky being clear till the descent was completed. From the general agreement of the results as observed by Regnault's hygrometer, and those of the dew-point as found by the dry and wet bulb thermometers, there can be no doubt that the temperature of the dew-point, at heights exceeding 30,000 feet, must have been as low as minus 50° below the zero of Fahrenheit's scale, or 82° below the freezing-point of water, implying that the air was very dry.



THE PIGEONS.

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THE DEPARTURE.

CHAPTER IV.

ASCENTS FROM THE CRYSTAL PALACE.

April 18, 1863.

In this ascent the balloon was partially filled during the evening of April 17, with the view of starting early the following morning. The atmosphere was at this time thick and misty; the wind on the earth was N.E., but pilot balloons on attaining a moderate elevation fell into a north current. The wind was moving at an estimated velocity of forty miles an hour, and the ascent was delayed hour after hour, in the hope that the upper current would change to N.E. At 1h., when the sky was nearly covered with clouds, and there were occasionally gleams of sunshine, the ascent was decided upon, although it was evident it could not be one of long duration, unless the wind changed its direction, or we resolved to cross the Channel. Whilst discussing this, the rope, our only connecting link with the earth, broke, and at 1h. 17m. we started very unceremoniously, the balloon taking a great lurch; I was thrown among my instruments, and unfortunately both Daniell's and Regnault's hygrometers were broken. Within three minutes we were more than 3,000 feet high. At 4,000 feet, cumulus clouds were on our level, and a thick mist rested everywhere on the earth. At 1h. 26m. we were 7,000 feet

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high, in a thick mist which almost amounted to a fog. The temperature of the air continued at 32° nearly, whilst that of the dew-point increased several degrees. On passing out of the cloud these two temperatures very suddenly separated, the latter decreasing rapidly; the sky was of a deep blue, without a cloud on its surface. At 1h. 30m. we were 10,000 feet high; directly under us was a sea of clouds. The towers of the Crystal Palace were visible, and by them we found we were moving south.

The temperature before starting was 61°; it decreased to 32° on reaching the cloud, and continued at this value whilst in it; then suddenly fell to 23¼° on leaving the cloud, and was either less or the same at every successive reading till we reached the height of 20,000 feet, where the lowest temperature was noticed. In passing above four miles the temperature increased to 14¼°, and then declined to 12¼° at the highest point, viz. 24,000 feet, at one hour and thirteen minutes after starting. When we were just four miles high, on descending, we began to reflect that possibly we might have been moving more quickly than we expected, and it was necessary to descend till we could see the earth below. The valve was opened rather freely at 2h. 34m., and we fell a mile in three minutes. We descended quickly, but less rapidly, through the next mile, and reached the clouds at 12,000 feet from the earth, at 2h. 42m. On breaking through them at 2h. 44m., still 10,000 feet from the earth, I was busy with my instruments, when I heard Mr. Coxwell exclaim, "What's that?" He had caught sight of Beechy Head. *I looked over the car, and the sea seemed to be under us.* Mr. Coxwell again exclaimed, "There's not a moment to spare; we must save the land at all risks. Leave the instruments." Mr. Coxwell almost hung to the valve-line, and told me to do the same, and not to mind its cutting my hand. It was a bold decision, opening the valve in this way, and it was boldly carried out.

When a mile high, the earth seemed to be coming up to us. There were two rents in the balloon, cut by the valve-line; these we could not heed. Up, up, the earth appeared to come, the fields momentarily enlarging; and we struck the earth at 2h. 48m. at Newhaven, very near the sea—of course with a great crash, but the balloon by the very free use of the valve-line had been crippled and never rose again, or even dragged us from the spot on which we fell. Nearly all the instruments were broken, and to my great regret three very delicate and beautiful thermometers, specially sent to me by M. A. d'Abbadie for these observations, were all broken. I was fortunate, however, in seizing and pocketing the aneroid barometer which had been up with

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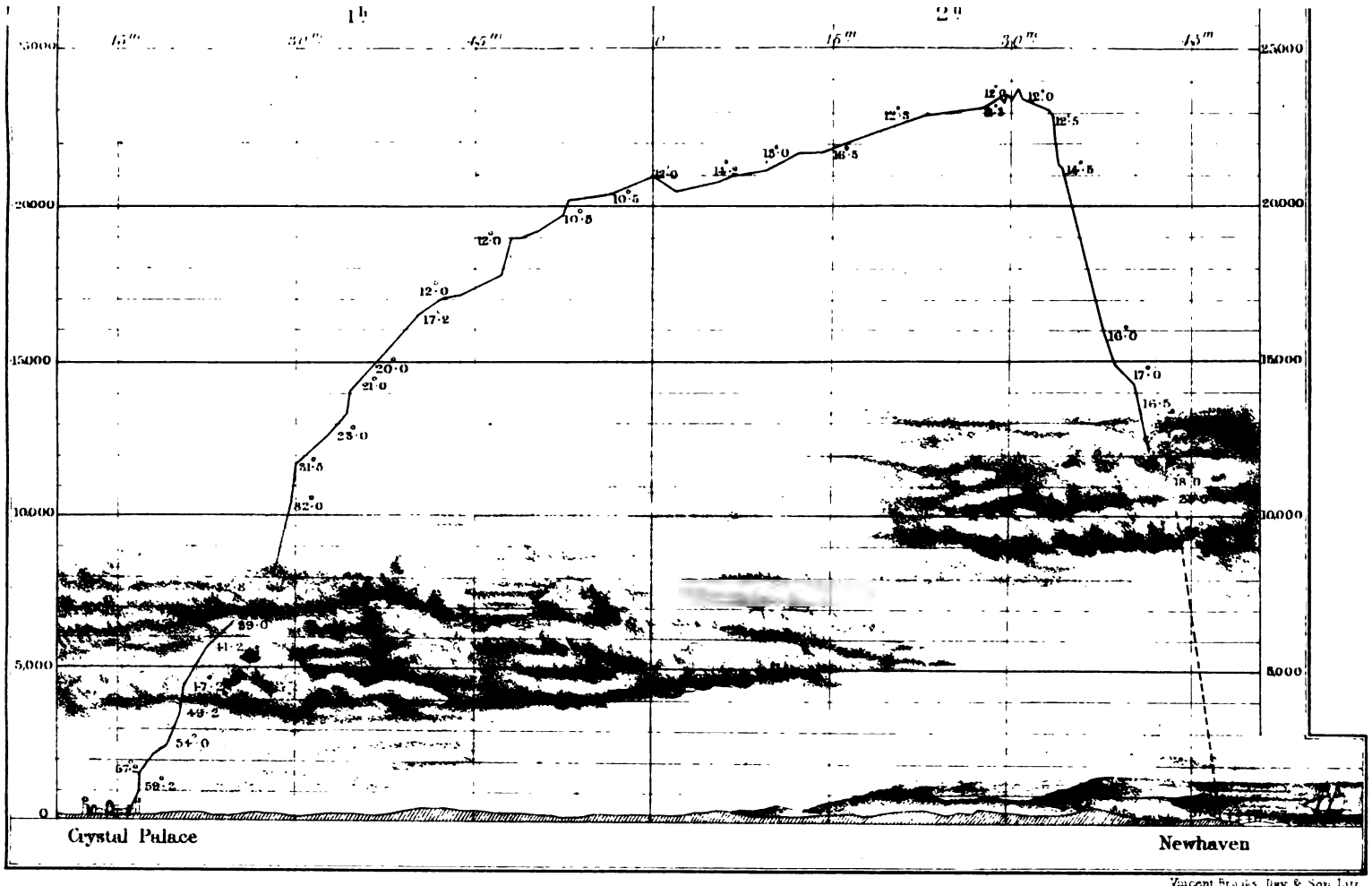

Path of the Balloon in its ascent from the Crystal Palace to New Haven
18th April 1863.

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me in every high ascent. It was this instrument that Mr. Coxwell read when we were seven miles high, and I at the time in a state of insensibility.

The diagram shows the path of the balloon. From this, it will be seen that the ascent was gradual from 16,000 feet to the highest point, and there was sufficient time for the instruments to attain the true temperature. We were above four miles for half an hour, not passing above 24,000 feet. On passing below four miles it would seem that the drop to three miles was nearly a straight line, and the next mile, though occupying a little more time, was passed quickly. The position of the clouds was fortunately very high, as is shown on the diagram, as well as the very rapid descent of two miles in four minutes. The whole time of descending the four miles and a quarter was about a quarter of an hour only. The diagram will speak to the eye more forcibly than language, showing as it does our close proximity to the sea, and the narrow escape from such a dangerous immersion.

JULY 11, 1863.

The ascent from the Crystal Palace, July 11, was intended to have been one of extreme height, and the promise of success in this respect was held out until near the time of starting, as pilot balloons had passed nearly due east, and indicated that our course would have been towards Devonshire; but so doubtful is the course a balloon will take, that no certainty can be felt till the balloon has actually left. However, on this occasion pilot balloons, though at first moving towards the east, soon met with a north wind and went south.

Under these circumstances, the attempt to ascend five miles was abandoned, and we resolved to ascertain, as far as possible, the thickness of the stratum influenced by the east wind, and if possible to profit by the knowledge and have as long a journey as we could.

At the time of leaving, 4h. 55m. P.M., the sky was nearly covered with cirrus and cirrostratus clouds, and the wind was blowing due east.

In about four minutes, and when at the height of 2,400 feet, the balloon suddenly changed from moving towards the west, to moving due south. At eight minutes past five we were over Croydon, at the height of 4,600 feet, in mist, but could see the Green Man Hotel, Blackheath; we then descended, passing downward through a thick atmosphere, till at 5h. 32m. we were 2,200 feet high over Epsom Downs, and again within the influence of the east wind. We then turned to ascend, and at 5h. 52m. were 3,000 feet above Reigate, and we here

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could see Shooter's Hill and the Crystal Palace, by the two towers of which we found we were again within the influence of a north wind.

We then continued to ascend, with the view of ascertaining if we could pass above the stratum which was under the influence of the north wind, at 6h. 16m.; when at 5,400 feet, the wind shifted to N.N.W., and the atmosphere became very thick and misty, the sun's place being just visible. At 6h. 28m. we were 6,600 feet high, and the sun was wholly obscured; we descended somewhat, but did not get below the mist. At 6h. 40m. we were 6,200 feet high, and directly over Horsham; and here I essayed to take a photograph, but from the mist by which we were surrounded, and the dark earth below —not lighted up at all—I did not succeed. We then ascended to 6,600 feet again to repeat the observations I had made, and found that the temperature at this elevation in the half-hour had declined 2° or 3°.

At this time, 6h. 56m., cirri and cirrostratus were very much higher than ourselves, and we saw the coast near Brighton. A consultation had been held whilst at this height, with the view of crossing over to France, but our progress being so slow, the circumstances did not promise success, so we came down with the view of again falling into the east wind, supposing it still to be prevalent. We met the north wind again at about 5,000 feet, and the east wind at exactly the same height, viz. 2,400 feet, at which we lost it on ascending. We descended to within 1,000 feet of the earth, and were near Worthing, at about five miles from the coast. We then ascended to 2,700 feet, and found ourselves moving towards the coast, and therefore within the influence of a north wind; evidently, therefore, if we wished to continue our journey, we must keep below 2,400 feet, otherwise we should be blown out to sea. When again at a height of 2,400 feet, we turned to move parallel to the coast, being at this time over Arundel. Sheep in the fields were evidently very frightened, and they huddled together. We now descended to 800 feet, and thus journeyed at heights varying from 800 to 1,600 feet, villagers frequently shouting to us to come down, and now and then answering our questions as to the locality we were in. The cheering cry of children was frequently heard above all other sounds. Geese cackled, and, frightened, scuttled off to their farms; pheasants crowed as they were going to roost, and as we approached the end of our journey packs of dogs barked in the wildest state of excitement, barking at the balloon. Journeying in this way was most delightful; all motion seemed transferred to the landscape itself, which appeared when looking one way to be rising and coming toward us, and when looking the other as receding from us. It was charmingly varied with parks,

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mansions, and white roads, and in fact all particulars to make up a rural scene of character extremely beautiful.

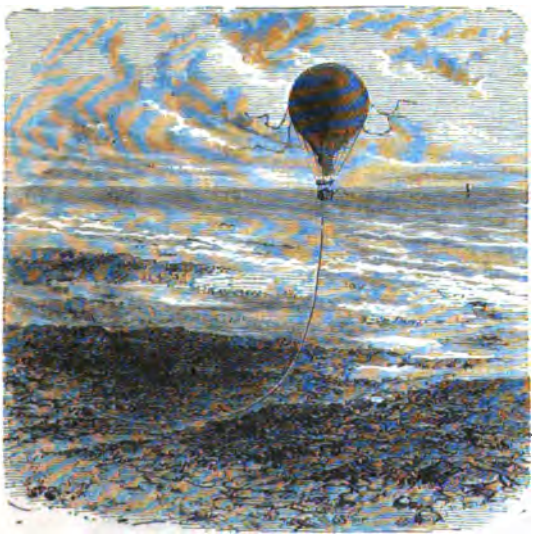
The temperature of the air was 75° on the ground, decreased to 63° at 2,600 feet, differed but little from 62° between 2,800 and 3,400, and then declined gradually to 55° at 5,000 feet; at heights exceeding 5,600 feet the temperature differed but little from 53°.

The direction of the wind on the ground was east, at 2,600 feet it was north, and at heights exceeding 5,400 feet it was N.N.W.

The humidity of the air passing from the east wind at 2,400 feet, to the north wind, increased greatly, and continued to increase till nearly 5,400 feet, when the direction of the wind changed to N.N.W., and at heights greater than this there were no clouds, but the air was very misty.

When we were at the height of 2,600 feet, flat-bottomed cumulus clouds were at our level. The clouds were entirely within the influence of the north wind, their under-sides were in contact with the east wind, with a much drier air, which at once dissipated all vapour in contact with it, and thus prevented the appearance of flat-bottomed clouds.

My friend Mr. Nasmyth, in a letter to me, says: "The flatness of the under-sides of the clouds during settled weather appears to me to rest on the upper surface of a stratum of air which appears to terminate at the line of flat bottom of the cloud." And these are the exact circumstances in which on this occasion I saw them.



DESCENT AT NEWHAVEN.

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BETWEEN TWO CLOUDS, FOUR MILES HIGH.

CHAPTER V.

ASCENT FROM WOLVERTON.

JUNE 26, 1863.

IN the ascent from Wolverton on the 26th June, the Directors of the North-Western Railway Company provided the gas, and gave every facility to members of the Committee of the British Association and their friends to be present. The gasometers at Wolverton are too small to hold gas enough to fill the balloon: it was therefore partly inflated the night before, and remained out all night without being influenced by the slightest wind. The morning of the ascent was also calm; the sky was of a deep blue, implying the presence of but little vapour. The atmosphere was bright and clear, and all the circumstances were of the most promising kind. The time of ascent was fixed to take place some little time after the express train from London should arrive, or at a little after noon; and the filling was somewhat delayed, the extraordinary fineness of the morning promising its completion in a short time. Between eleven and twelve all these favourable circumstances changed; the sky became covered with clouds, and some of them of a stormy character. The wind arose and blew strongly; the balloon lurched a great deal. Great difficulty was experienced in passing the gas into the balloon, and sufficient could not be passed in by one o'clock. The wind was momentarily

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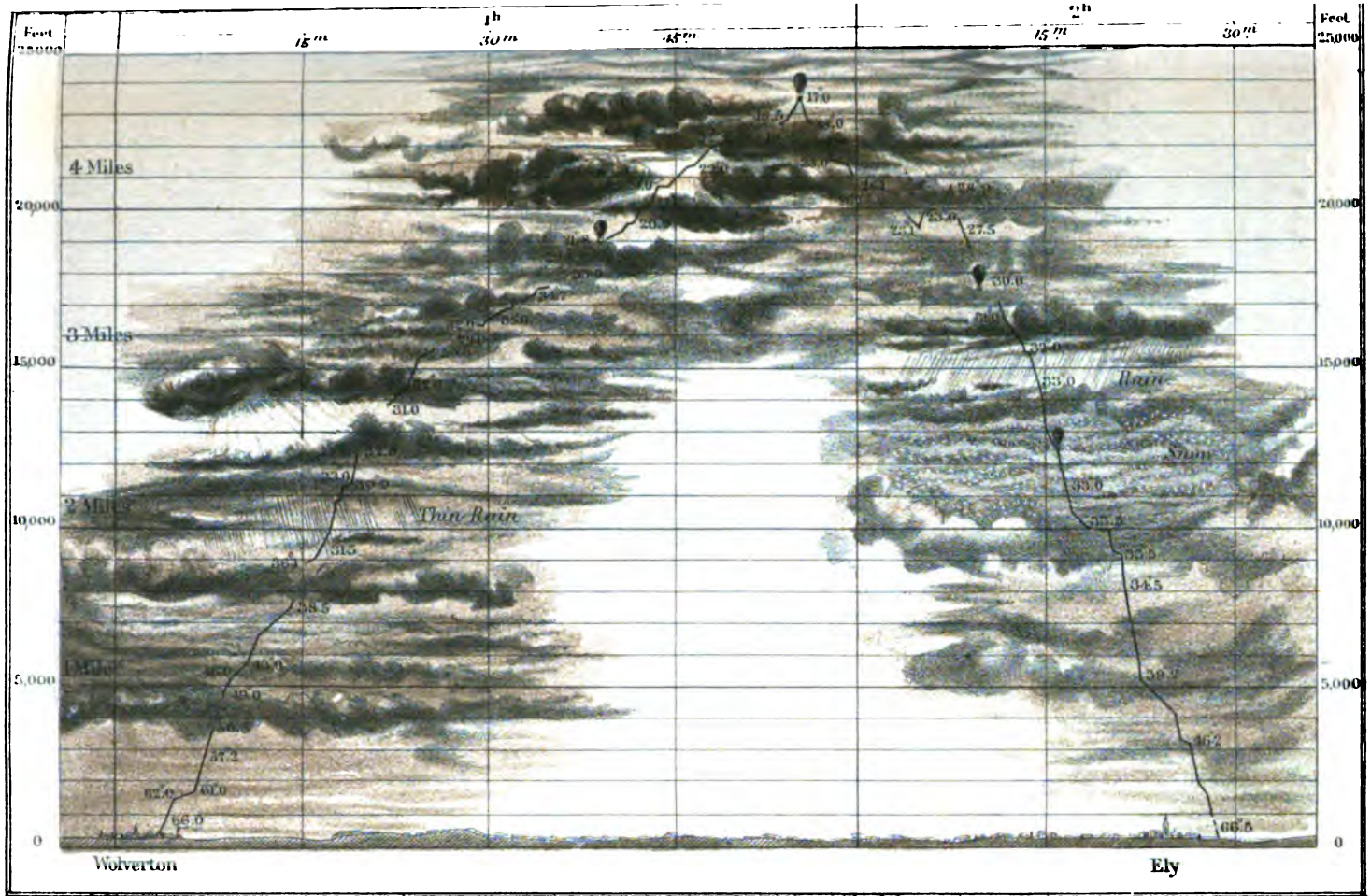

Path of the Balloon in its ascent from Wolverton to Ely.
26th June, 1863.

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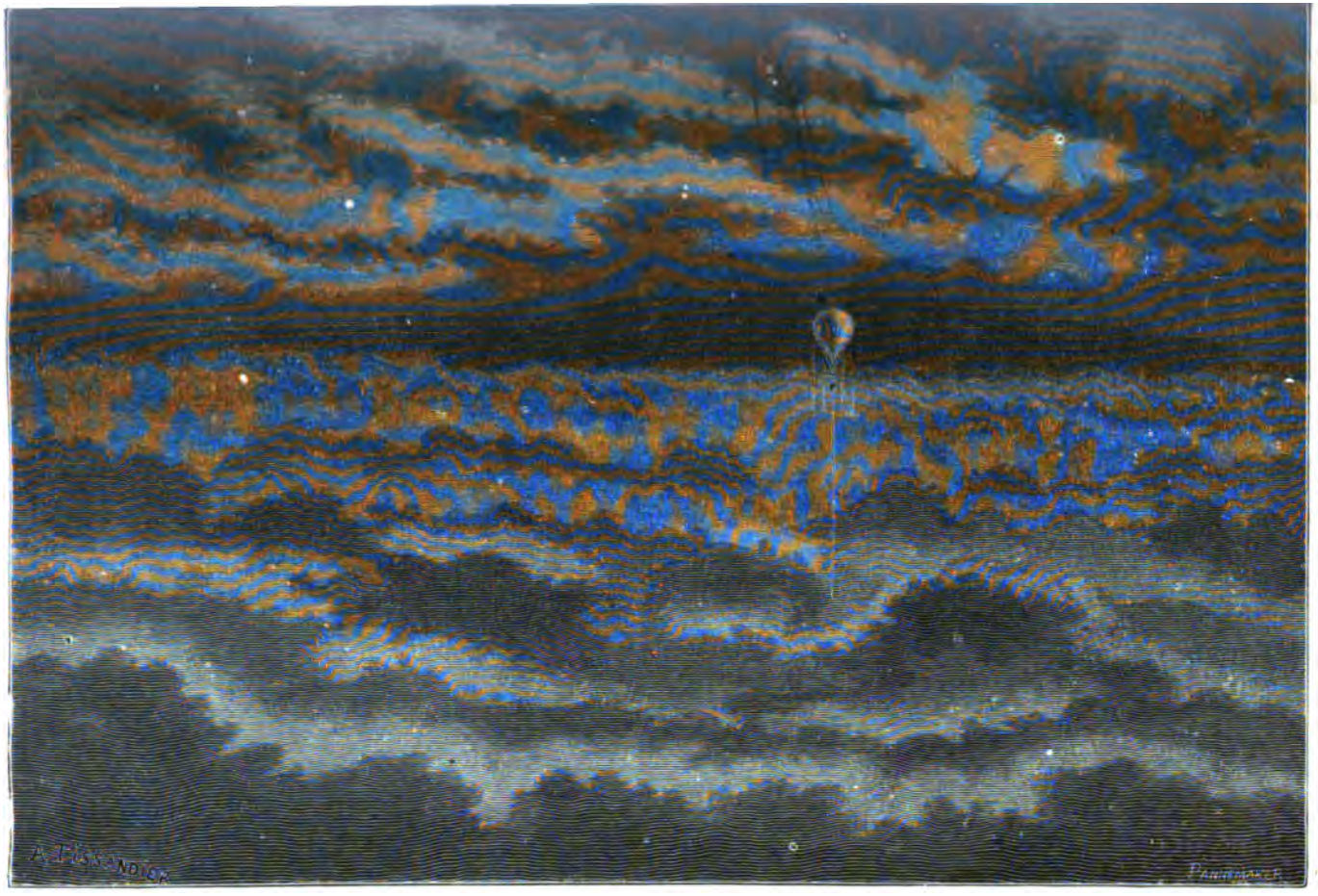

THREE MILES HIGH: "CLOUDS BELOW US, OTHERS ON OUR LEVEL AT A DISTANCE, AND YET MORE ABOVE."

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increasing, and it became very desirable to be away. The greatest difficulty was experienced in fixing the instruments, and some were in great danger of being broken by the violent swaying of the balloon and the incessant striking of the car upon the ground, notwithstanding the exertions of fifty men to hold it fast. At the time of leaving, the spring-catch was jammed so tight by the pressure of the wind that it would not act, and we were let free by the simultaneous yielding of the men, and had to part instantly with ballast to avoid striking adjacent buildings.

It was three minutes after one when we left the earth, with a strong W.S.W. wind: the temperature 65°. In four minutes we were 4,000 feet high, and entered a cloud with a temperature of 50°, experiencing a most painful feeling of cold. As on all previous occasions, we expected soon to break through the clouds into a flood of strong sunlight, with a beautiful blue sky, without a cloud above us, and with seas of rocky clouds below. But, on the contrary, when we emerged, it was dark and dull. Above us there were clouds. At 9,000 feet high we heard the sighing, or rather moaning of the wind as preceding a storm: it was the first time that I had heard such a sound in the air. We satisfied ourselves that it was in no way attributable to any movement of the cordage about the balloon, but that it was owing to conflicting currents of air beneath. At this time we saw the sun very faintly, and momentarily expected its brilliancy to increase, but instead of this, although we were now two miles high, we entered a fog, and entirely lost the sight of it. Shortly afterwards fine rain fell upon us. Then we entered a dry fog, and at 12,000 feet passed out of it; saw the sun again faintly for a short time, and then entered a wetting fog. At 15,000 feet we were still in fog, but it was not so wetting. At 16,000 feet we entered a dry fog; at 17,000 feet saw faint gleams of the sun, and at the same height we heard a train. We were now about three miles high. As we looked around there were clouds below us, others on our level at a distance, and yet more above. We looked with astonishment at each other, and said that as we were rising steadily we must surely soon pass through them.

At 17,500 feet we were again enveloped in fog, which became wetting at 18,500 feet. We left this cloud below at 19,600 feet. At 20,000 feet the sun was just visible. We were now approaching four miles high; clouds, dense clouds, were still above us; for a space of 2,000 to 3,000 feet we met with no fog, but on passing above four miles high our attention was attracted to a dark mass of cloud, and then to another on our level. Both these clouds had fringed edges, and were unmistakably nimbi. Without the slightest doubt they

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were both rain-clouds. Whilst looking at them we again lost sight of everything, being enveloped in fog whilst passing upwards through 1,000 feet. At 22,000 feet we emerged again, and were above clouds on passing above 23,000 feet. At six minutes to two we heard a railway train: the temperature here was 18°. I still wished to ascend to find the limits of this vapour, but Mr. Coxwell knew better, and I was met with a negative: "Too short of sand. I cannot go higher; we must not even stop here." I was therefore most reluctantly compelled to abandon the wish, and looked searchingly around. At this highest point, in close proximity to us, were rain-clouds; below us, dense fog. I was again reminded that we must not stop here. With a hasty glance everywhere, above, below, all around, I saw the sky nearly covered with dark clouds of a stratus character, with cirri still higher, and small spaces of faint blue sky between them; the blue was not the blue of four or five miles high, as I had always before seen it, but a faint blue, as seen from the earth when the air is charged with moisture.

Hastily glancing over the whole scene, there was no extensive, fine, or picturesque views, as in such situations I had always before seen. The visible area was limited; the atmosphere was murky; the clouds were confused, and the aspect everywhere dull.

I cannot avoid expressing the surprise I have felt at the extraordinary power which a situation like this calls forth, when it is felt that a few moments only can be devoted to note down all appearances and all circumstances at these extreme positions; and if not so rapidly gleaned, they are lost for ever. In such situations every appearance of the most trivial kind is noticed; the eye seems to become keener, the brain more active, and every sense increased in power to meet the necessities of the case; and afterwards, when time has elapsed, it is wonderful how distinctly, at any moment, scenes so witnessed can be recalled and made to reappear mentally in all their details, so vividly, that had I the power of the painter I could reproduce them visibly to the eye upon the canvas.

We then began our downward journey, wondering whether we should meet the same phenomena. Soon we were enveloped in a fog, but passed below it when at 22,000 feet, and then we saw the sun faintly. At 20,000 feet we were in a wetting fog, and passed beneath it at 19,500 feet, experiencing great chilliness; fog was then above and below. I now wished to ascend into the fog again, to check the accuracy of my readings as to its temperature, and the reality of the chill we had felt. This we did: the temperature rose to its previous reading, and fell again on descending.

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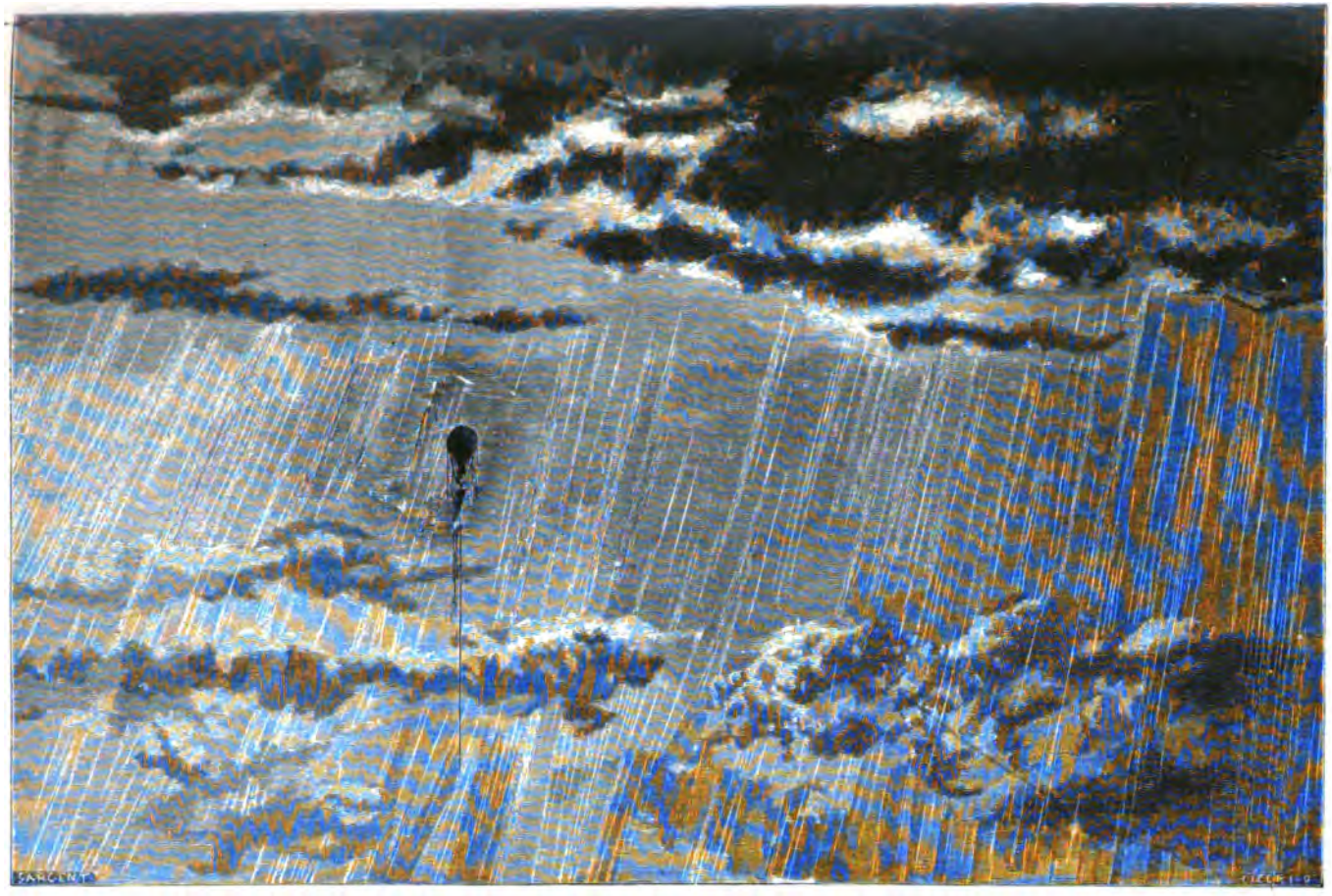

"RAIN FELL PATTERING ON THE BALLOON."

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For the next 1,000 feet we passed down through a thick atmosphere, but not in cloud or fog. At the height of 18,000 feet we were again in fog. At three miles high we were still in fog, and on passing just below three miles, rain fell pattering on the balloon. This was one mile higher than we experienced rain on the ascent, but it was much heavier. On passing below 14,000 feet, and for a space of nearly 5,000 feet, we passed through a beautiful snowy scene. There were no flakes in the air—the snow was entirely composed of spiculæ of ice, of cross spiculæ at angles of 60°, and an innumerable number of snow crystals, small in size, but distinct and of well-known forms, easily recognizable as they fell and remained on the coat. This unexpected meeting with snow on a summer afternoon was all that was needed on this occasion to complete the experience of the characteristics of extreme heat of summer with the cold of winter within the range of a few hours. On passing below the snow, which we did when about 10,000 feet from the earth, we entered a murky atmosphere which continued till we reached the ground; indeed, so thick and misty was the lower atmosphere, that although we passed nearly over Ely Cathedral and not far from it, we were unable to see it. When 5,000 feet high, we were without sand and simply became a falling body, the rapidity of the fall being checked by throwing the lower part of the balloon into the shape of a parachute. The place of descent was in a field on the borders of the counties of Cambridge and Norfolk, twenty miles from the mouth of the Wash, and eight miles from Ely.

This Wolverton ascent must rank among the most extraordinary of my series, giving scientific data of high interest and results most unexpected. The leading features will be most readily seen by looking at the diagram, on which the black line shows the path of the balloon, and the figures near to it the temperature of the air, which will be seen to decrease from 65° to 18° at the highest point, and to increase to 66° again on descending to the earth. By following the path, clouds will be seen to be reached at 4,000 feet, and above this an attempt has been made to show to the eye at a glance the varying strata and their situations, through which we passed. The bent arrows in the ascending track are placed where we heard the moaning of the wind. The faint blue just above is where we saw the sun and momentarily expected to come within its influence. The rain which fell at 10,000 feet, the partially clear spaces and those of more or less dense fog in the ascent to the highest point, and the appearance of the sky there, are clearly seen in the diagrams; as well as the place of re-ascension, in the downward journey to which I have referred. The clear spaces

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are those where we were out of fog at 14,000 feet. At a lower level will be seen the snowstorm of 5,000 feet in thickness, and below that the thick and misty atmosphere till the earth was reached.

ASCENT FROM THE CRYSTAL PALACE.

JULY 21, 1863.

The weather on this day was bad, the sky overcast and rainy. Although in every respect a thoroughly bad day, it was well suited to a particular purpose I had in view, viz.: to investigate, if possible, some points concerning the formation of rain in the clouds themselves; to determine why a much larger amount of rain is collected in a gauge near the surface of the earth than in one placed at an elevation in the same locality, and whether during rain the air is saturated completely; or, if not, to what extent; also to discover the regulating causes of a rainfall, which sometimes occurs in large drops, at others in minute particles.

So long back as the years 1842 and 1843 I made many experiments in order to ascertain why so great a difference in volume was found to exist in the water collected at lower stations as compared with that collected at higher.

The experiments which yielded the best results were those in relation to temperature.

I always found that when the rain was warm, with respect to the temperature of the air at the time, no difference existed in the quantities of rain collected at different heights; but when the temperature of the rain was lower than the temperature of the air, a considerable difference existed.

From this circumstance it would appear probable that the difference in the quantities of rain collected at different heights is owing (at least in part) to the great condensation of the vapour in the lower atmosphere, through being in contact with the relatively cold rain.

In this ascent I desired to confirm or otherwise Mr. Green's deductions.

This gentleman believing that whenever a fall of rain happens from an overcast sky there will invariably be found to exist another stratum of cloud at a certain elevation above the first, I determined, if I found it so, to measure the space between them and the thickness of the upper stratum, and to ascertain whether the sun was shining on its upper surface.

We left the earth at 4h. 52m., and in ten seconds had ascended into the mist; in twenty seconds, to a level with the clouds, but not through them. At the height of 1,200 feet we passed out of this rain.

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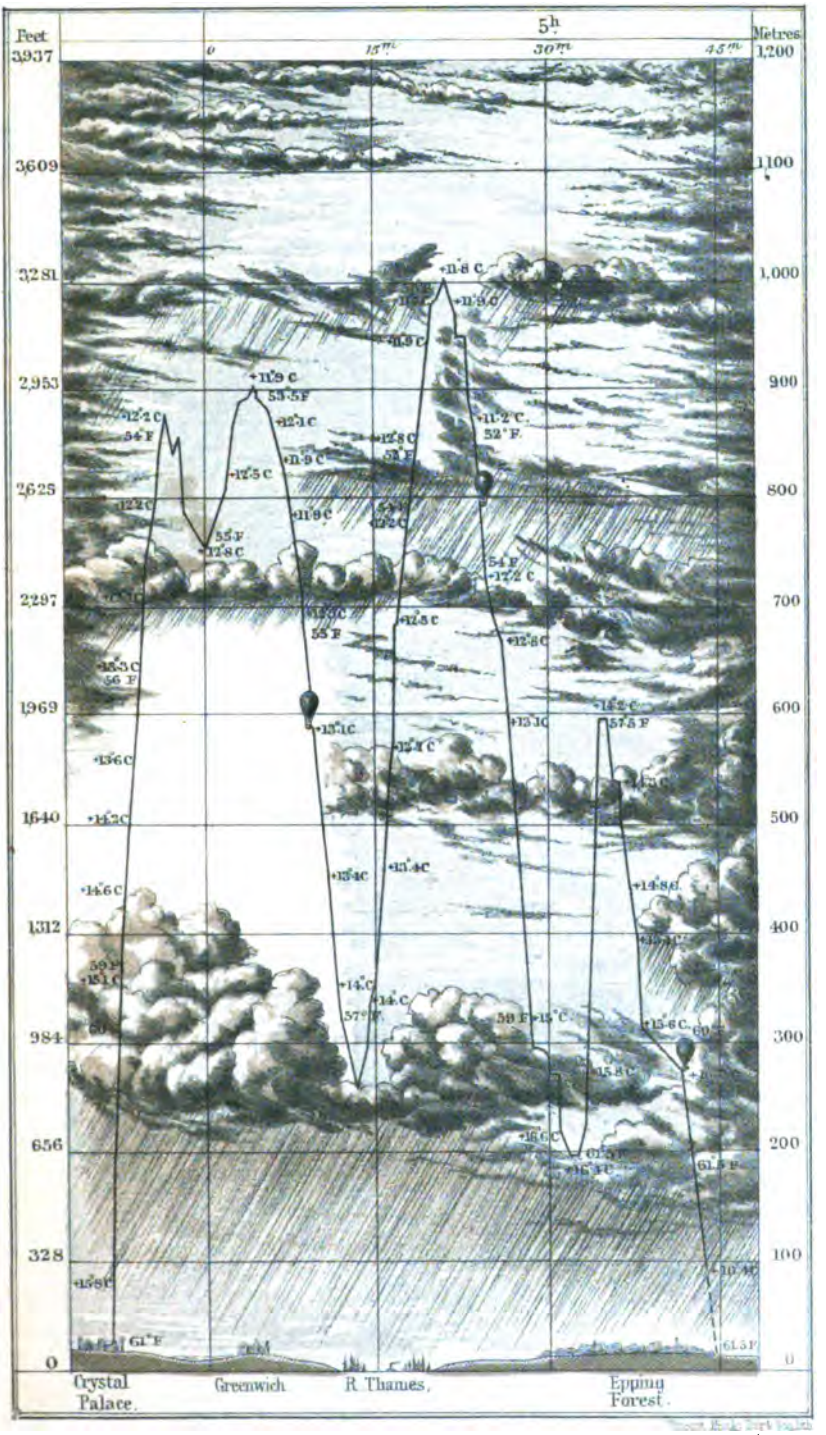

Path of the Balloon in its ascent from the Crystal Palace to Epping Forest, 21st July 1863.

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At the height of 2,800 feet we emerged from clouds, and saw a stratum of darker cloud above; we then descended to 800 feet, over the West India Docks, and saw rain falling heavily upon the earth. None fell upon the balloon; that which we saw, therefore, had its origin within 800 feet of the ground.

We ascended again, and this time passed upwards through fog 1,400 feet in thickness.

At 3,300 feet we were out of cloud, and again saw the dark stratum at a distance above; clouds obscured the earth below.

On descending, at 2,700 feet we entered a dry fog, but it became wetting 100 feet lower down. After passing through 600 feet of it, the clouds became more and more wetting, and below were intensely black.

At 5h. 28m. we were about 700 feet high, or about 500 feet above Epping Forest, and heard the noise of the rain pattering upon the trees.

Again we ascended to 2,000 feet; then through squalls of rain and wind descended to 200 feet, the rain-drops being as large as a fourpenny-piece, the same as when we left the earth.

On reaching the earth, we found that rain had been falling heavily all the time we were in the air.

Thus this journey gave more information about rain than we ever before had gained, and which could be obtained by means of the balloon alone.

NIMBI, OR RAIN-CLOUDS, ABOVE FOUR MILES HIGH.

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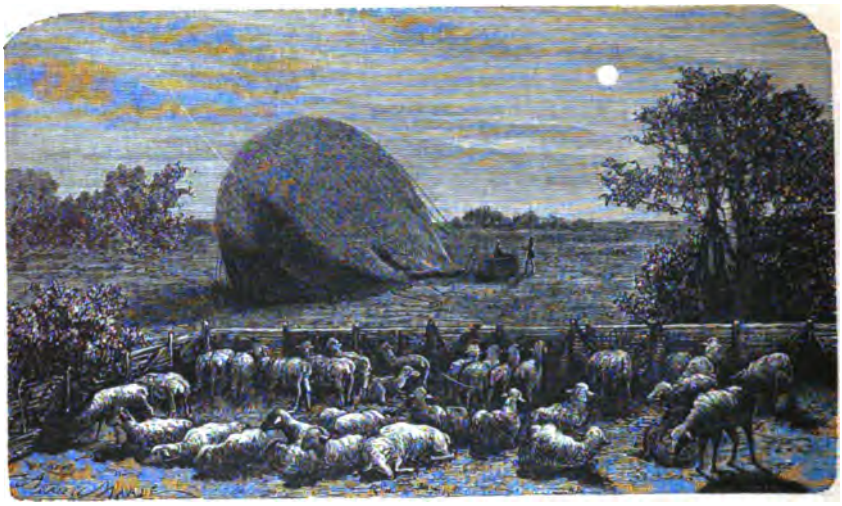

THE DESCENT.

CHAPTER VI.

ASCENT FROM WINDSOR.

May 29, 1866.

No ascent had been made in May, and I was anxious to make one in this month. Mr. Westcar, of the Royal Horse Guards, then stationed at Windsor, kindly offered the use of his balloon, and arrangements were made for ascents at different times in May, but, as is usual, some fruitless attempts were made.

On the 29th of May the balloon was filled early in the afternoon, and we left at 6h. 14m., about an hour and three-quarters before sunset, in the hope of being able to remain in the air for as long a time after sunset.

The temperature of the air at this time was 58°, and 58½° at Greenwich Observatory. It at once declined on leaving the earth to 55° at 1,200 feet, and to 43° between the heights of 3,600 to 4,600 feet, then further declining to 29½° at the height of 6,200 feet, at 7h. 17m. On descending, the temperature increased, but not uniformly, to 54° at 8h. 9m. at 380 feet above the sea, when, however, we were nearly touching the tops of the trees, there being about 3° of less temperature when at the same height above the sea on rising. Our object was to be as near the earth as possible at the time of sunset,

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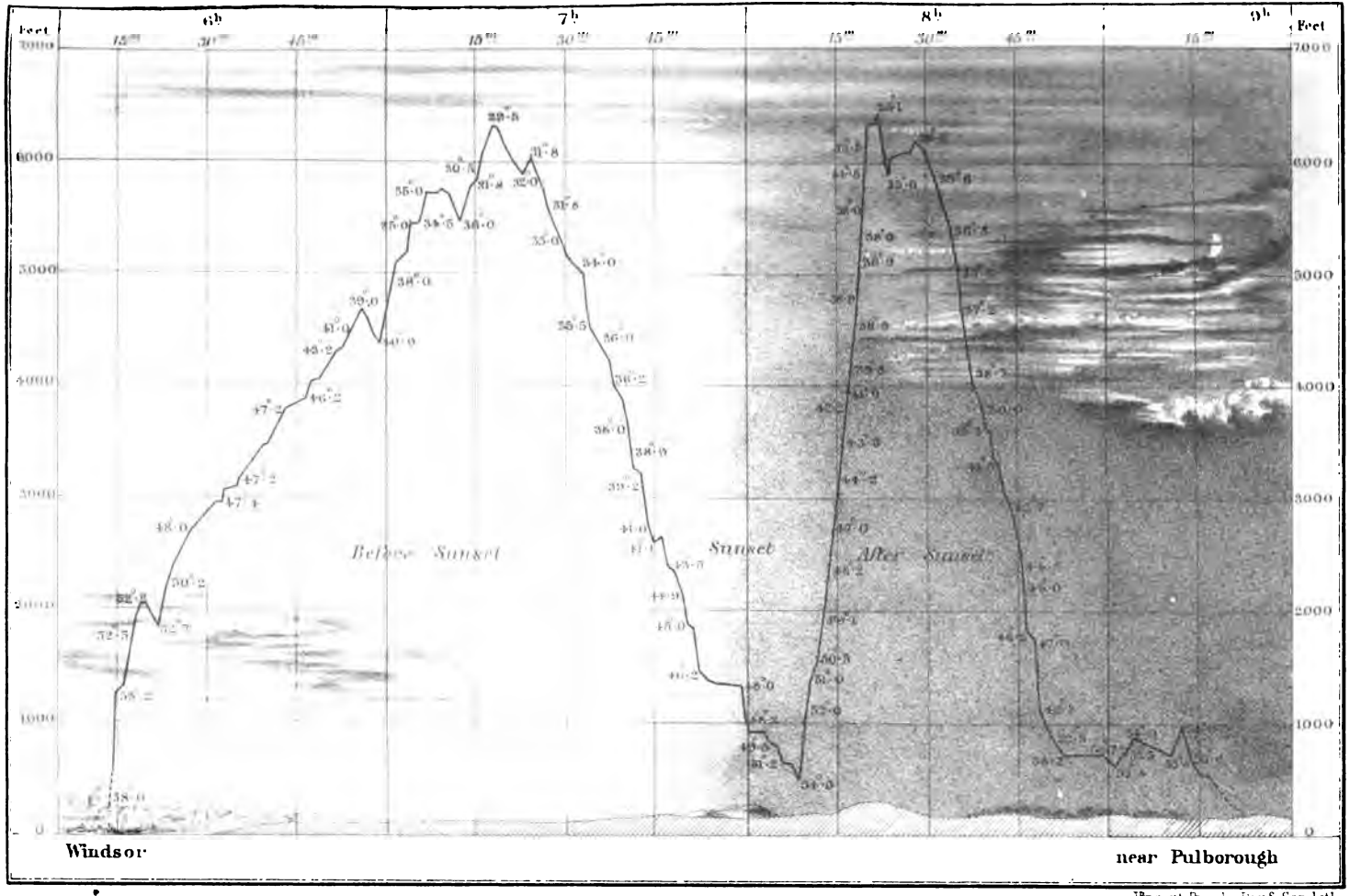

Vincent Brooks Day & Son, Lith.

Path of the Balloon in its ascent from Windsor to near Pulborough
29th May 1866.

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and, afterwards, to discharge sand so quickly as to see sunrise again in the west. We did not succeed. At the time of sunset we were about 600 feet high, but had just passed over a hill, and on passing the ridge the balloon had been sucked down, so that it was only by a free discharge of sand that Mr. Westcar prevented the balloon coming to the ground. We then again started upon a second ascent, to be as like the one we had just completed as we could make it. At 8h. 9m. the temperature was 54°. Again the temperature declined, but somewhat less rapidly than before. On again reaching one mile the temperature had declined to 39°, and on reaching the height of 6,200 feet (the same elevation as we were three-quarters of an hour before sunset), the sun having set nearly twenty minutes, the temperature was 35°, or about 6° warmer than when at the same elevation something more than one hour before. On descending, the temperature changed very little, being 35° to 36° for a thousand feet downwards. It increased to 37° at 4,500, to 47° at 1,500, and to 54° at 900 feet; but here the increase was checked, and at 600 feet the temperature was 52¾°; on ascending a little, again the temperature increased, it decreased on descending, and was 50¼° on the ground at a spot 300 feet above the sea, at half-past eight o'clock. At Greenwich at this time the temperature of the air was 52°.

At the time of leaving the earth at 6h. 14m. the air at Greenwich had but three grains of moisture in a cubic foot. At Windsor, near the Thames, there were 4½ grains; the air was damp: on ascending the air at first became drier, but at the height of one mile was saturated, and was very nearly saturated at the same height after sunset.

Thus the double ascent enables us to compare the temperatures of the same elevations, just before and just after sunset on the same day, and to estimate the amount of heat radiated from the earth at about the time of sunset.

At heights exceeding 2,000 feet the direction of the wind was N. by W.; at the height of one mile the air was nearly calm; and at heights less than 2,000 feet it was N. by E., and these currents were met with always at those elevations.

At all times during the ascent, whenever the sun shone upon a transparent bulb, or a dull blackened bulb thermometer, the reading was a very little in excess of the reading of a shaded bulb, and was frequently the same even when the sun's heat felt sensibly warm.

The path of the balloon from Windsor was over Windsor Great Park; nearly over Woking at 7h. 43m.; a little west of Guildford, where, approaching the coast, at half-past nine, we calculated that the

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sea must be near, and we descended at a place five miles south of Pulborough.

My attention was almost wholly occupied with the observations; Mr. Westcar's chiefly with the management of the balloon: he frequently, however, read the several instruments, particularly those whose bulbs were exposed to the sun's rays.

The safety lamp was burning all the time, thus enabling the instruments to be read after dark.

I till recently believed that this was the first ascent for scientific purposes, since that of Biot and Gay-Lussac in 1804, in which the management of the balloon was undertaken by the experimentalists themselves. But I find I am in error in this respect. My friend l'Abbé Moigno tells me that MM. Bixio and Barral, in the year 1850, took the entire management of the balloon in their own hands.

On descending, nearly one hour and a half after sunset, there was no one near to assist us to empty and pack the balloon. This we had to do ourselves, and we were preparing to pass the night in the car of the balloon, when towards midnight a shepherd came by, and we passed the night in his cottage at the distance of half a mile, leaving the balloon, &c., in the fields till the morning.

The temperature of the air declined from 58° on the ground to 52° at 2,000 feet, and somewhat more rapidly to 46°·7 at 3,000 feet; it increased to 48°·7, or by 2°, in the next 400 feet, and then gradually declined to 29°·8 at the height of 6,200 feet. On descending, the temperature increased gradually to 48°·3 at 1,000 feet, and then much more rapidly to 53°·6 at the height of 500 feet: this rapid increase was remarkable. On turning to ascend, the sun having set, the temperature declined pretty equally to the height of 4,000 feet, and at greater heights with somewhat less regularity, to 34° at 6,000 feet, when the temperature increased to 35°·3 at the height of 6,400 feet: this increase was very remarkable. On descending again, the temperature increased with moderate regularity to 48°·7 at the height of 1,300 feet, and then with much greater rapidity to 53°·8 at the height of 600 feet, when the increase was arrested, and the temperature at lower elevations rapidly declined to 50°·1 on reaching the earth. This decline of temperature from 600 feet is remarkable. By comparing the readings at the same heights before and after sunset, it will be seen that at the height of 6,000 feet the temperature was from 5° to 6° warmer after sunset than it was before sunset, and that the temperatures on the ground and at 1,000 feet high were nearly the same, whilst at intermediate heights they were much higher.

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The degree of humidity of the air increased from the ground to the height of 500 feet; from this height to 1,200 feet the air was somewhat less humid, and still less so at heights exceeding 1,200 feet. At the height of 3,400 feet the degree of humidity was 57 only; the air was again wet at 4,800 feet, and somewhat less so at heights exceeding 5,000 feet. On descending, the humidity of the air was more uniform down to the height of 3,400 feet, and below this the air was less humid than at the same elevations on the ascent, particularly at low elevations. On descending below 400 feet, I packed up the instruments for fear of the balloon striking the ground; at this time the sun was setting. On ascending again, after sunset, the air was more and more humid, and most so at 6,300 feet; the same result we found in the descent, to the height of 600 feet, where the degree of humidity was 61; and it increased to 68 on the ground.

THE COTTAGE.

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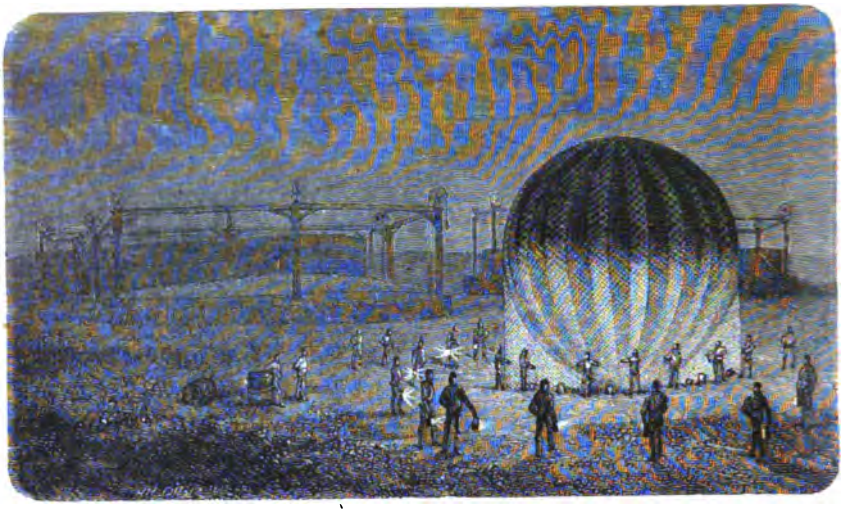

FILLING A BALLOON.

CHAPTER VII.

OVER LONDON BY DAY.

March 31, 1863.

The day was favourable; the wind was from the east, in gentle motion; the sky was blue and almost cloudless. The earth was left at 4h. 16m. P.M., and we passed upwards with very nearly an even motion to the height of 19,000 feet, continued at about this level for some little time, and then gradually ascended to 24,000 feet, which we reached at 5h. 28m., or in one hour and twelve minutes after starting. We then let out gas, and never have I seen the opening of the valve exercise such an effect, for though it seemed to be but momentary, we fell in consequence a mile and a quarter in four minutes. Happily we had enough sand to contend with this difficulty, and checked the descent by parting with it, and for half an hour we kept nearly upon the same level, between 15,000 and 16,000 feet high. After this we gradually and almost continuously fell, and reached the earth at 6h. 26m., effecting the descent in fifty-eight minutes from the place where the balloon was at its secondary station.

The temperature of the air on the earth on leaving was 50°. At 4h. 25m., at the height of one mile, it was 33½°; the second mile was reached at 4h. 35m., with a temperature of 26°; the third mile at 4h. 44m., when the temperature was 14°; and at 3¾ miles high the

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temperature was 8°. A warm current of air was here met with, and the temperature rose to 12° at 4h. 58m.; at 5h. 2m. the warm current was passed, and when 4½ miles high the temperature was just zero of Fahrenheit's scale.

In descending, the temperature increased to 11°, at about three miles high; then a cold current was met with, and it fell to 7°. This was soon passed, and the temperature increased to 18½° at two miles high, to 25½° at one mile, and to 42° on the ground, showing a decrease of 8° of temperature during the 2h. 10m. between the two observations. On comparing the readings of thermometers at the same height during the ascents with those during the descents, all the latter were lower, showing that the whole mass of air was of lower temperature than that in immediate contact with the earth, but to a smaller amount. The air was dry before leaving; it became very dry at heights exceeding two miles, and at heights exceeding four miles the temperature of the metallic cup of Regnault's hygrometer was lowered to nearly minus 40°, and no dew was deposited on its surface. The temperature of each layer of air was different, according to its direction of motion, and there were several currents met with. Within two miles of the earth the wind was east; between two and three miles high it was directly opposite, viz. west. About three miles it was north-east; higher still it changed to the opposite—south-west; and from about four miles to the highest point reached, it was west.

We left the Crystal Palace, therefore, with an east wind, and at about 4h. 48m. the Palace appeared directly under us.

When one mile high the deep sound of London, like the roar of the sea, was heard distinctly; its murmuring noise was heard at greater elevations. At the height of three and four miles the view was indeed wonderful: the plan-like appearance of London and its suburbs; the map-like appearance of the country generally; and the winding Thames, leading the eye to the white cliffs at Margate and on to Dover, were sharply defined. Brighton was seen, and the sea beyond, and all the coast line up to Yarmouth. The north was obscured by clouds. Looking underneath, and to the south, there were many detached cumuli clouds, and in some places a solitary cloud; all apparently resting on the earth. Towards Windsor the Thames looked like burnished gold, and the surrounding water like bright silver. Railway trains were like creeping things, caterpillar-like, and the steam like a narrow line of serpentine mist. All the docks were mapped out, and every object of moderate size was clearly seen with the naked eye. Taking a grand view of the whole visible area beneath, I was struck with its great regularity: all was dwarfed to one plane; it

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seemed too flat, too even, apparently artificial. The effect of the river scenery in this respect was remarkable; the ships, visible even beyond the Medway, looked like toys.

At the height of three miles and a half Mr. Coxwell said my face was of a glowing purple, and higher still both our faces were blue. At heights exceeding three miles, our feet and the tips of our fingers were very cold. The sky was of a deep prussian blue. When three miles high, on descending, Mr. Coxwell, forgetful of the fact that the grapnel had been exposed to a temperature of zero, incautiously took hold of it with his naked hand, and cried out, as in pain, that he was scalded, and called on me to assist in dropping it. The sensation was exactly that of scalding. The blackness creeping over the land at sunset, whilst the sun was still shining on us, was remarkable. We reached the ground at 6h. 3m., near Barking, in Essex.

OVER LONDON BY NIGHT.

Ascent from Woolwich Arsenal, October 2, 1865.

When the sun had set for nearly three-quarters of an hour, and night had fairly set in, the moon shining brightly, and the sky free from cloud, the balloon left Woolwich Arsenal at 6h. 20m., the temperature at the time being 56°. Within three or four minutes a height of 900 feet was reached, and till this time I had failed in directing the light of the Davy lamp properly. When I succeeded, the temperature was 57° and increasing; on reaching 1,200 feet high it had increased to 58°·9. We then descended to 900 feet, and the temperature decreased to 57·8; on beginning to ascend again the temperature increased to 59°·6 at 1,900 feet high, being 3½° warmer than when the earth was left. On descending again the temperature decreased to 57½° at the height of 600 feet, and in the several subsequent ascents and descents the temperature increased with elevation, and decreased on approaching the earth. On every occasion the highest temperature was met with at the highest point. This result was remarkable indeed. The different degrees of the humidity of the air met with in this ascent are no less remarkable. Considering saturated air as represented by 100, at the commencement of the ascent in the balloon it was 95; at Greenwich Observatory it was 84; towards the end of the ascent in the balloon it was 85, and at Greenwich was 97. The state of things was therefore reversed, and would indicate that the water in the air had fallen. Its amount at the beginning of the ascent was 5¼ grains in a cubic foot of air, and at the same elevation was 4½ grains in the same mass of air at the end of the ascent.

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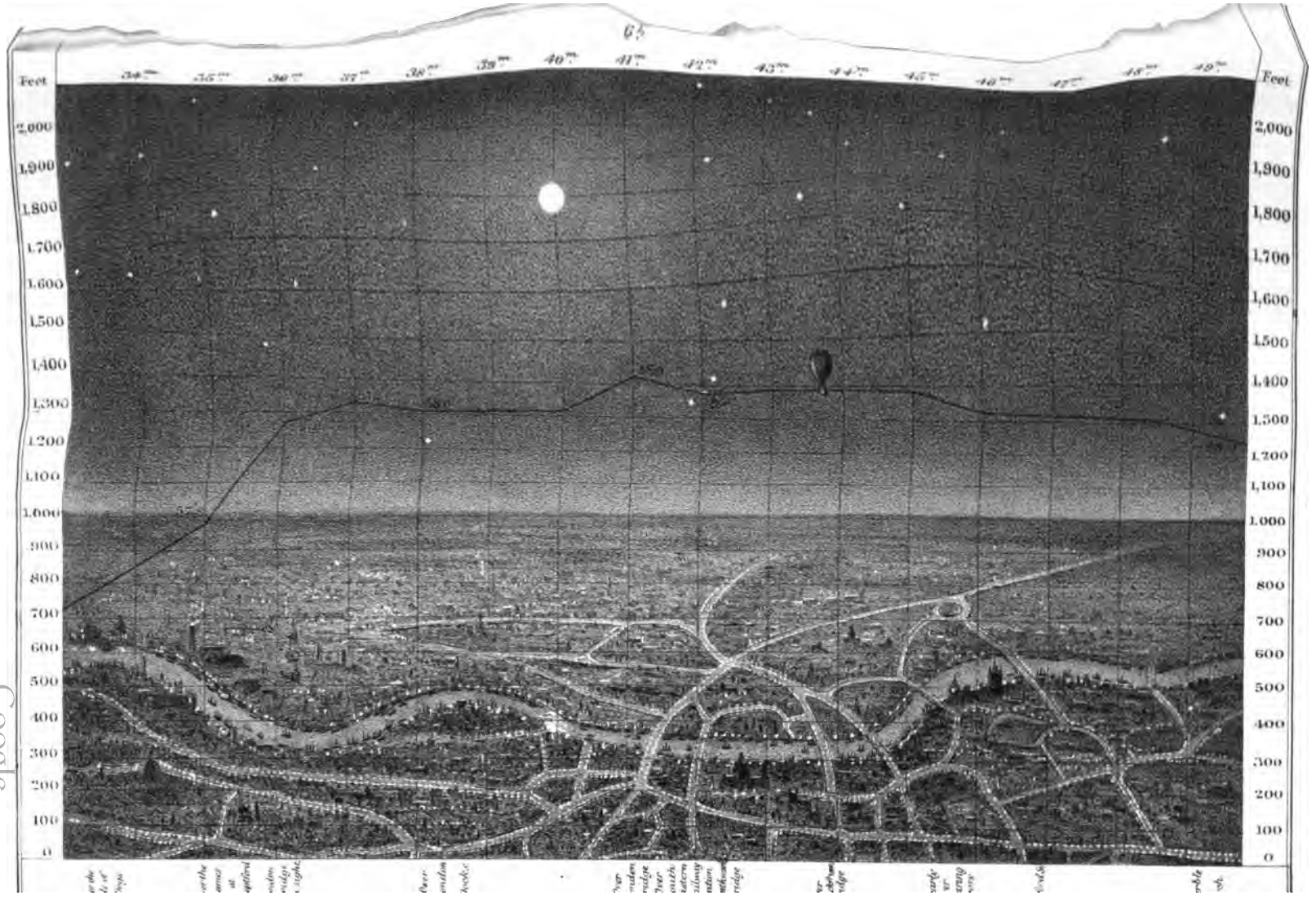

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The readings of the instruments were taken very slowly, owing to the difficulty experienced in directing the light properly. I failed in all magnetic experiments, and indeed in nearly all but those relating to temperature and humidity. Two self-registering minimum thermometers were tied down, one with its bulb resting on cotton wool, fully exposed to the sky, and the other with its bulb projecting beyond the supporting frame; their indexes were at the end of their columns of spirit on starting, or at 56°. At every examination of each of these instruments a space was found between its index (which remained unmoved) and the end of the column of spirit, indicating a temperature higher than before leaving, and it was closely approximate at all times to the temperature of the air. Consequently, notwithstanding the clearness of the sky, the loss of heat by radiation must have been small. No ozone was shown at the Royal Observatory, but in the balloon paper tests were coloured to 4, on a scale where greatest intensity was considered 10.

At the early part of this ascent I was wholly occupied with the instruments, and when at the height of about 1,000 feet the view which suddenly opened far exceeds description. Almost immediately under, but a little to the south-east, was Woolwich; north was Blackwall; south, Greenwich and Deptford; and west, as far as the eye could reach, was London—the whole forming a starry spectacle of such brilliancy as far to exceed anything I ever saw. When I have been at this elevation in the evening, at a distance from London, it has had the appearance of a vast conflagration, but on this night the air was so clear and free from haze that each and every light was distinct, and they seemed all but touching each other.

The whole of Woolwich, Blackwall, Deptford, and Greenwich could be traced as a perfect model by the line of lights of their streets and squares. In nine minutes we were opposite Brunswick Pier, Blackwall, crossing the Thames; we then passed across the Isle of Dogs, Greenwich Reach, and so up the river Thames. As we advanced towards London, the mass of illumination increased in intensity. At 6h. 42m. the South-Eastern Railway Terminus at London Bridge was directly under us; looking southward at this time we saw the Borough stretching far away, and the many streets shooting from it, particularly Southwark Street, with its graceful curve of lamps. In one minute more we were over Southwark Bridge, 1,300 feet high, passed Blackfriars Bridge at 6h. 45m., and Charing Cross at 6h. 47m.

On leaving Charing Cross I looked back over London, the model of which could be seen and traced—its squares by their lights; the

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river, which looked dark and dull, by the double row of lights on every bridge spanning it. Looking round, two of the illuminated dials of Westminster clock were like two dull moons. Again, looking eastward, the whole lines of the Commercial and Whitechapel roads, with their continuations through Holborn to Oxford Street, were visible, and most brilliant and remarkable. We were at such a distance from the Commercial Road that it appeared like a line of brilliant fire, assuming a more imposing appearance when the line separated into two, and most imposing just under us in Oxford Street. Here the two thickly-studded rows of brilliant lights were seen on either side of the street, with a narrow dark space between, and this dark space was bounded, as it were, on both sides by a bright fringe like frosted silver. At first I could not account for this appearance; but presently, at one point more brilliant than the rest, persons were seen passing, their shadows being thrown on the pavement, and at once it was evident this rich effect was caused by the bright illumination of the shop-lights on the pavements.

I feel it impossible to convey any adequate idea of the brilliant effect of London, viewed at an elevation of 1,300 feet, on a clear night, when the air is free from mist.

It seemed to me to realize a wish I have felt when looking through a telescope at portions of the Milky Way, when the field of view appeared covered with gold-dust, to be possessed of the power to see those minute spots of light as brilliant stars; for certainly the intense brilliancy of London this night must have rivalled such a view.

We were over the Marble Arch at 6h. 51m., about eleven miles in a straight line from Woolwich, which distance had been passed in about half an hour. We therefore were travelling at more than twenty miles an hour. On passing onwards we left the Edgeware Road on our right, and the Great Western Railway on our left, and passed nearly down the Harrow Road. In six or seven minutes we left the suburbs of London, passing over Middlesex in the direction of Uxbridge: there the contrast was great indeed; not a single object could anywhere be seen, not a sound reached the ear; the roar of London was entirely lost. The moon was shining, but seemed to give no light; and the earth could not be seen. After a time the moon seemed to shine with increased brightness; the fields gradually came into view, then the shadow of the balloon on the earth was seen distinctly pointing out our path, which, by reference to the pole-star and the moon, became well known to us. After this, occasional masses of lights appeared as we passed over towns and villages. Thus we passed out of Middlesex, over parts of

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Buckinghamshire and Berkshire, to Highmoor, in Oxfordshire, where we descended on the farm of Mr. Reeves at 8h. 20m., distant about forty-five miles from Woolwich. The horizontal movement of the air at Greenwich in the same time was registered as sixteen miles.

Unfortunately, Mr. Orton believed we were near the sea, and, notwithstanding my assertions and assurances to the contrary, he suddenly brought the balloon to the ground, and broke nearly all the instruments; the lamp was lost, but an offered reward brought it to me a fortnight afterwards in a very battered condition.

The results of this first night experiment are very valuable; and, so far as one experiment can give, indicate that on a clear night the temperature, up to a certain elevation, increases with increase of elevation.

The temperature of the dew-point increased on ascending to the height of 900 feet, then decreased, the air becoming drier, or the degree of humidity less; at heights exceeding 1,200 feet the degree of humidity was nearly the same as at heights less than 900 feet. On descending, the temperature of the dew-point decreased, and the air was driest at about the height of 1,000 feet; at heights less than 1,000 feet the temperature of the dew-point increased, and the degree of humidity increased till the ground was reached.

The temperature of the air was the lowest on the ground, and increased with elevation to the height of 2,000 feet, the highest point attained; and on the descent it decreased with decrease of elevation, and was lowest on reaching the ground.

THE SUBURBS OF LONDON IN THE DISTANCE.

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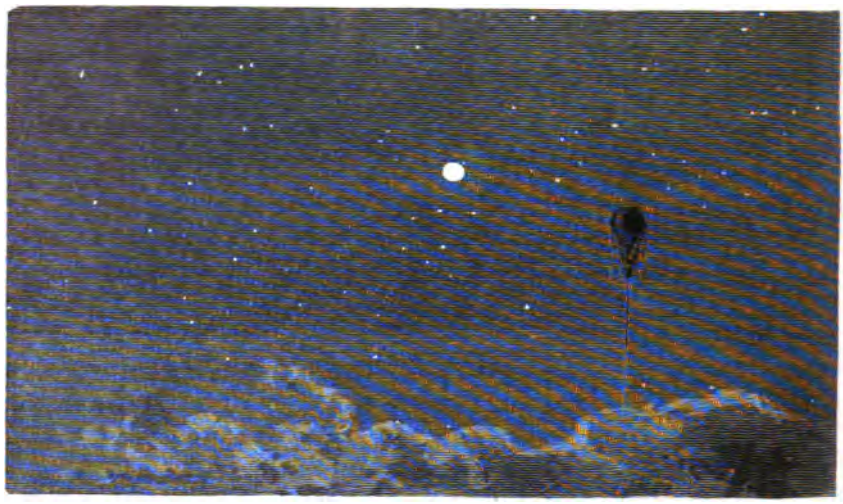

"THE MOON WAS SHINING, BUT SEEMED TO GIVE NO LIGHT."

CHAPTER VIII.

DECREASE OF TEMPERATURE WITH ELEVATION.

THE few ascents which I have chosen are sufficient to show that the decrease of temperature is very far from constant. It follows, therefore, that we must entirely abandon the theory of a decline of one degree of temperature for every increase of 300 feet of elevation. It is necessary to renounce this ideal regularity upon which we have been dependent in determining the co-efficient of refraction. The differences have been immense; even with a clear sky, the most favourable for establishing a mean, the figures vary very greatly—that is to say, within 100 feet near to the earth we now know there may be a decline of temperature of several degrees during the mid-hours of the day, and that during the mid-hours of the night there may be, and generally is, an increase of several degrees.

The decline of temperature near the earth was found to be different according to the more or less cloudy state of the sky, being more rapid when the latter was clear than when cloudy; it was, therefore, found necessary to separate the experiments made in one state of the sky from those made in the other. Collecting the results together, the general result of all the mid-day experiments is as follows:—

The change from the ground to 1,000 feet high was 4°·5 with a cloudy sky, and 6°·2 with a clear sky. At 10,000 feet high it was

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2°·2 with a cloudy sky, and 2°·0 with a clear sky. At 20,000 feet high the decline of temperature was 1°·1 with a cloudy sky, and 1°·2 with a clear sky. At 30,000 feet high the whole decline of temperature was found to be 62°. Within the first 1,000 feet the average space passed through for 1° was 223 feet with a cloudy sky, and 162 feet with a clear sky. At 10,000 feet the space passed through for a like decline was 455 feet for the former, and 417 feet for the latter; and above 20,000 feet high the space with both states of the sky was 1,000 feet nearly for a decline of one degree.

As regards the law thus indicated, it is far more natural and far more consistent than that of a uniform rate of decrease. The results here spoken of have relation to experiments made during the hours of the day; near the earth they do not hold good during the hours of the night, nor are they of universal application during the day, as the following experiences will prove.

In my ascent on January 12, 1864, the temperature of the air before starting was 41½°; it then decreased very slowly till 1,300 feet was reached, when a warm current was met with, and at 3,000 feet the temperature was 45°, being 3½° warmer than on the ground, and for the next 3,000 feet the temperature was higher than on the earth. It then gradually fell to 11° at 11,500 feet, and remained at this reading till 12,000 feet was reached.

In this ascent the wind on the earth was S.E. At the height of 1,300 feet the balloon entered a strong S.W. current. This direction continued up to 4,000 feet, when the wind was from the S. At the height of 8,000 feet the wind changed to S.S.W., and afterwards to S.S.E. At 11,000 feet we met with fine granular snow, and passed through snow on descending, till within 8,000 feet of the earth. We entered clouds at 7,000 feet, and passed out of them at 6,000 feet into mist.

A warm current of air was met with, of more than 3,000 feet in thickness, moving from the S.W.; that is to say, in the direction of the Gulf Stream. This was the first time a stream of air of higher temperature than on the earth had been encountered. Above this the air was dry, and higher still very dry. Fine granular snow was falling into this current of warm air.

The meeting with this S.W. current is of the highest importance, for it goes far to explain why England possesses a winter temperature so much higher than is due to our northern latitudes. Our high winter temperature has hitherto been mostly referred to the influence of the Gulf Stream. Without doubting the influence of this natural agent, it is necessary to add the effect of a parallel atmospheric

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current to the oceanic current coming from the same regions—a true aërial Gulf Stream. This great energetic current meets with no obstruction in coming to us or to Norway, but passes over the level Atlantic without interruption from mountains.

It cannot, however, reach France without crossing Spain and the lofty range of the Pyrenees, and the effect of these cold mountains in reducing its temperature is so great, that the former country derives but little warmth from it.

I will now say a few words in relation to the very exceptional temperatures met with in my ascent of 6th of April, 1864. This ascent had been arranged to take place as near to March 21 as possible, but the weather was so exceptionable that, although frequent attempts were made, it was not till the 6th of April that an ascent could be made.

On that day the balloon left Woolwich at 4h. 7m. P.M., with a S.E. wind. In nine minutes, when at the height of 3,000 feet, we crossed over the river Thames, ascending very evenly at the rate of 1,000 feet in three minutes, till 11,000 feet was reached, at 4h. 37m. We then descended at about the same rate, till within 1,500 feet of the earth, when we checked the rapidity of the descent, and reached the ground on the outskirts of a pine plantation in Wilderness Park, near Sevenoaks, in Kent.

This ascent is remarkable for the small decrease in temperature with increase of elevation. The temperature of the air was 45½° on leaving the earth; *it did not decline at all* till after 300 feet had been passed, and then it decreased pretty gradually to 33° when 4,300 feet was reached; a warm current was then entered, and the temperature increased to 40° at 7,500 feet, the same as at 1,500 feet; it decreased to 34° at 8,800 feet, and then increased slowly to 37° nearly, at 11,000 feet, a temperature which had been experienced at the heights of 8,500, 6,500, and at 3,000 feet in ascending.

On descending, the temperature increased about 9° in the first 1,000 feet; and after remaining at about this temperature till within 7,000 feet of the earth, it gradually decreased to 40° at 3,000 feet, remained at about this point till within 1,500 feet of the earth, and then increased to 46° on the ground.

Our course in this ascent was most remarkable. After passing over the Thames into Essex, we must have recrossed the river, and moved in an entirely opposite direction till we approached the earth again, when our direction was the same as at first.

The temperatures met with on June 13, 1864, are also very remarkable. On this occasion the balloon left the grounds of the Crystal Palace

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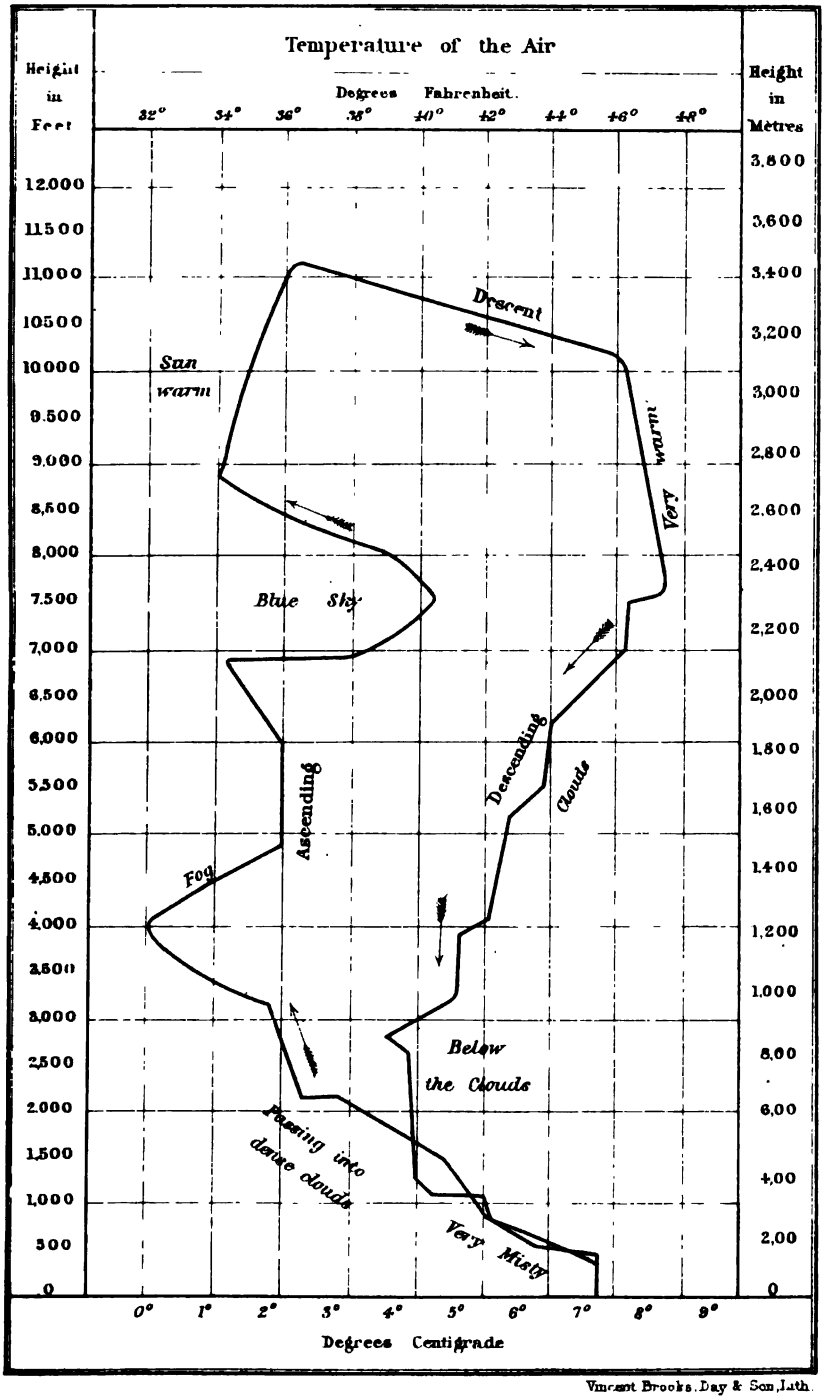

Vincent Brooks, Day & Son, Lith.

Temperature of the Air at different heights observed in the Ascent and descent.

6th April 1864.

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UNIV. OF MICH.

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at seven o'clock. The sky was cloudless and the air perfectly clear, excepting in the direction of London. An elevation of 1,000 feet was reached in 1¼ min. and 3,000 feet at 7h. 8m., when the balloon began to descend, and passed down to 2,300 feet by 7h. 13m.; on re-ascending 3,400 feet was gained at 7h. 20m.; after taking a slight dip the balloon again ascended to 3,550 feet (the highest point) by 7h. 28m.; it then descended to 2,500 feet, and, after several small ascents, began the downward journey at 7h. 50m. from the height of 2,800 feet, and reached the ground at East Horndon, five miles from Brentwood, at 8h. 14m.

The temperature of the air on the ground before starting was 62°, declining evenly with increase of elevation till 3,000 feet was reached, when it was 51½°; on descending, the temperature was found to be 54° at 2,300 feet; the balloon then re-ascended, the temperature declining gradually to 3,100 feet, when it began to increase, reaching 49° at 3,450 feet, above which height it declined to 47° at 3,540 feet; on again descending it increased evenly, till at 2,700 feet the thermometer read 51°, and remained about the same for 200 feet; on re-ascending the temperature scarcely differed from 51° till 3,000 feet was gained, when a sudden decrease of 2° occurred in the following 35 feet; then began our final descent, the temperature remaining the same for 400 feet; it then increased to 51½° at 2,000 feet, and to 53°·2 at 1,800 feet, below which there was scarcely any alteration till the earth was reached. This fact of no change in the temperature of the air at the time of sunset was very remarkable, for it indicated that if such on this occasion was not an accidental circumstance, the law of decrease of temperature with increase of elevation might be reversed at night for some distance from the earth.

From all the experiments it appeared that the change of temperature near the earth varied greatly in different ascents, and followed no constant law. It no doubt depended on the time of day; but the ascents were so few in number and so irregularly scattered over the months of the year, that I was unable to determine the law even approximately.

The great Captive Balloon at Ashburnham Park seemed admirably adapted to settle this point, and M. Giffard, its proprietor, most kindly placed it at my disposal for any series of experiments I was desirous of making. The balloon on a calm day could ascend to the height of 2,000 feet, its rate of ascent and descent could be regulated at will, and it could be kept stationary at any elevation. The observations made in nearly thirty ascents are published in the Transactions of the Sections in the Report of the Meeting of the British Association at Exeter, 1869.

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The numbers in those Tables verify the indications of the several free ascents, viz. that the decrease of temperature with increase of elevation has a diurnal range, and depends upon the hour of the day, the changes being the greatest at mid-day and the early part of the afternoon, and decreasing to about sunset, when with a clear sky there is little or no change of temperature for several hundred feet from the earth, whilst with a cloudy sky the change decreases from the mid-day hours at a less rapid rate to about sunset, when the decrease is nearly uniform and at the rate of 1° in 200 feet. I was not able to take any observations after sunset; but such observations are greatly needed, as there seems to be a very great probability that the temperature at the height of 1,000 feet may not undergo a greater range of temperature during the night than during the day hours; and if this be the case, the temperature at night must increase from the ground with elevation. This inference seems to be confirmed by the after-sunset observations of Oct. 2, 1865, but it is very desirable and important that the fact should be verified or contradicted by direct experiments. The law with a clear sky may be thus represented. Take the heights as ordinates of a curve of which the corresponding changes of temperature are the corresponding abscissæ (considered positive when the temperature decreases, *i.e.* so that a decrease of 10° at 1,000 feet would correspond to a point on the curve whose positive abscissa is 10 and ordinate 1,000): then the curve thus formed will be somewhat hyperbolic (for the changes are greatest near the earth), the concavity being turned towards the origin, which we may call the axis. The concavity will be greatest when the curve represents the decline of temperature at a time soon after mid-day; but as the afternoon advances the curve gradually closes up to and coincides with the axis at or about sunset, becoming then rectilinear; after passing this critical position, in which the temperature is uniform and equal to that on the earth for the first 1,000 feet, the curve probably becomes hyperbolic again, its concavity still being turned towards the axis, so that an increase of temperature corresponds to an increase of height, and the extreme position is reached probably at or soon after midnight, when the curve returns as before, the motion being probably nearly symmetrical on both sides of the axis, and the time of a complete oscillation twenty-four hours. These changes, however, are confined to the lower regions of the atmosphere: at heights exceeding a certain elevation varying with the season of the year, there can be no doubt that the general law shows a continuous decline with elevation.

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THE ANEROID BAROMETER.

The first aneroid barometer which I had made for these observations read correctly at 30 inches, and 0·1 inch too high at 25 inches; the error increased to 0·7 inch at 14 inches, but decreased to 0·5 inch at 11 inches. A second aneroid read very nearly the same as the mercurial barometer, from 30 inches to 12 inches. A third graduated down to 5 inches, and, most carefully made and tested under the air-pump before use, read the same as the mercurial barometer throughout the high ascent to seven miles on Sept. 5, 1862. I have taken this instrument up with me in every subsequent high ascent, and it has always read the same as the mercurial barometer. These experiments prove that an aneroid can be made to read correctly at low pressures. I may mention that on several occasions aneroid barometers have been taken whose graduations have been too limited for the heights reached: these have not broken or become deranged by being subjected to a much less pressure than they were prepared for, but have resumed their readings on the pressure again coming within their graduations.

BLACKENED BULB THERMOMETER.

A dull, blackened bulb thermometer, *in vacuo*, with its bulb projecting beyond the car in such a position as to receive all the sun's rays, and to show their maximum effect, never read but a few degrees higher than the temperature of the air, whilst another placed with its bulb near to the centre of the table carrying the several instruments read several degrees higher still; but in no instance has the blackened bulb thermometer, after leaving the earth, read as high as it did when exposed to the full rays of the sun on the earth.

The fact that the readings of a blackened bulb thermometer with its bulb projecting into space, free from the influence of any body near to it, were lower than those of a similar thermometer placed with its bulb near to a body upon which the sun's rays are arrested, is in agreement with all similar experiments I have made. In my paper "On the Radiation of Heat from the Earth," published in the *Philosophical Transactions* for 1847, I have remarked that a thermometer with its bulb in free space, so as to be fully in the passing sunbeams at the height of 14 feet from the soil, never read higher than an instrument placed in air, shaded from the sun in the hottest day in summer.

From all these experiments it seems that the heat rays, in their passage from the sun, pass the small bulb of a thermometer, communicating very little or no heat to it. Similar results were obtained by

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the use of Herschel's actinometer on every occasion that I had an opportunity of using it.

THE LINES IN THE SPECTRUM.

At every examination, when the spectroscope was directed to the sun, a magnificent spectrum was seen, with very numerous lines, extending from A to far beyond H, the latter line appearing not nebulous, but made up of many very fine lines; at times no spectrum was seen, when the spectroscope was directed to the sky far from the sun.

TIME OF VIBRATION OF A MAGNET.

In every ascent I made many attempts to obtain the time of vibration of a horizontal magnet at different elevations in the higher regions of the atmosphere, but I failed at every trial in the ascents on August 31, Sept. 29, Oct. 9, Jan. 12, April 6, June 13, and June 20. In the ascent on June 27 there were frequent periods of ten to fifteen minutes when the car was very steady, so that I was enabled to take the time of vibration as accurately as on the ground. The results of ten different sets of observations proved undoubtedly that the time of vibration was longer than on the earth. In the ascent on August 29 the balloon was constantly revolving both in ascending and descending, but was free from oscillation for fully a quarter of an hour at the highest point, viz. nearly three miles, and the time of vibration was again found to be longer than on the earth.

DIFFERENT DIRECTIONS OF THE WIND AT DIFFERENT ELEVATIONS.

The balloon in almost every ascent was under the influence of currents of air in different directions. The thicknesses of these currents were found to vary greatly. The direction of the wind on the earth was sometimes that of the whole mass of air up to 20,000 feet nearly, whilst at other times the direction changed within 500 feet of the earth. Sometimes directly opposite currents were met with at different heights in the same ascent, and three or four streams of air more than once were encountered moving in different directions.

THE VELOCITY OF THE WIND.

Notwithstanding the different currents of air which caused the balloon to change its direction, and at times to move in entirely opposite directions; yet, neglecting all these and all upward and downward motion, and simply taking into account the places of ascent and descent, the distances thus measured were always very

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much greater than the horizontal movement of the air as measured by anemometers. It may be interesting to note some instances of this, which are as follows:—

Velocity of the Wind by the Balloon, and by Robinson's Anemometer at the Royal Observatory, Greenwich.

On March 31, 1863, the balloon left the Crystal Palace, Sydenham, at 4h. 16m. P.M., and fell at Barking, in Essex, a point fifteen miles from the place of ascent, at 6h. 30m. P.M. Neglecting all motion of the balloon, excepting the distance between the places of ascent and descent, its hourly velocity was seven miles; the horizontal movement of the air of Greenwich, as shown by Robinson's anemometer, was five miles per hour.

On April 18 the balloon left the Crystal Palace at 1h. 16m. P.M., and descended at Newhaven at 2h. 46m. The distance is about forty-five miles, passed over in an hour and a half, or at the rate of thirty miles per hour. Robinson's anemometer had registered less than two miles per hour.

On June 26 the balloon left Wolverton at 1h. 2m. P.M., and fell at Littleport at 2h. 28m. P.M. The distance between these two places is sixty miles; the hourly velocity was therefore forty-two miles per hour. The anemometer at Greenwich registered ten miles per hour.

On July 11 the balloon left the Crystal Palace at 4h. 53m. P.M., and fell at Goodwood at 8h. 50m. P.M., having travelled seventy miles, or at the rate of eighteen miles per hour. The anemometer at Greenwich registered less than two miles per hour.

On July 21 the balloon left the Crystal Palace at 4h. 52m. P.M., and fell near Waltham Abbey, having travelled about twenty-five miles in fifty-three minutes, or at the rate of twenty-nine miles per hour. The horizontal movement of the air by Robinson's anemometer was at the rate of ten miles per hour.

On September 29, 1864, the balloon left Wolverhampton at 7h. 43m., and fell at Sleaford, a point ninety-five miles from the place of ascent, at 10h. 30m. A.M. During this time the horizontal movement of the air was thirty-three miles, as registered at Wrottesley Observatory.

On October 9 the balloon left the Crystal Palace at 4h. 29m. P.M., and descended at Pirton Grange, a point thirty-five miles from the place of ascent, at 6h. 30m. P.M. Robinson's anemometer during this time registered eight miles at the Royal Observatory, Greenwich, as the horizontal movement of the air.

On January 12, 1865, the balloon left the Royal Arsenal, Woolwich, at 2h. 8m. P.M., and descended at Lakenheath, a point seventy miles

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from the place of ascent, at 4h. 19m. P.M. At the Royal Observatory, by Robinson's anemometer, during this time the motion of the air was six miles only.

On April 6 the balloon left the Royal Arsenal, Woolwich, at 4h. 8m. P.M. Its correct path is not known, as it entered several different currents of air, the earth being invisible owing to the mist; it descended at Sevenoaks, in Kent, at 5h. 17m. P.M., a point fifteen miles from the place of ascent. Five miles was registered during this time by Robinson's anemometer at the Royal Observatory, Greenwich.

On June 13 the balloon left the Crystal Palace at 7h. 0m. P.M., and descended at East Horndon, a point twenty miles from the place of ascent, at 8h. 15m. P.M. Robinson's anemometer during this time registered seventeen miles at the Royal Observatory, Greenwich.

On August 29 the balloon left the Crystal Palace at 4h. 6m. P.M., and descended at Weybridge at 5h. 30m. P.M., a point thirteen miles from the place of ascent. During this time fifteen miles was registered by Robinson's anemometer at the Royal Observatory, Greenwich.

PHYSIOLOGICAL OBSERVATIONS.

The number of pulsations usually increased with elevation, as also the number of inspirations: the number of my pulsations was generally 76 per minute before starting, about 90 at 10,000 feet, 100 at 20,000 feet, and 110 at higher elevations; but the increase of height was not the only element, for the number of pulsations depended also on the health of the individual. They also, of course, varied in different persons, depending much on their temperament. This was the case, too, in respect to colour; at 10,000 feet the face of some would be of a glowing purple, whilst others would scarcely be affected. At 17,000 feet my lips were blue; at 19,000 feet both my hands and lips were dark blue; at four miles high the pulsations of my heart were audible, and my breathing was very much affected; at 29,000 feet I became insensible. From all the observations it would seem that the effect of high elevation affected every one, but was different upon the same individual at different times.

ON THE PROPAGATION OF SOUNDS.

It was at all times found that sounds from the earth were more or less audible, according to the amount of moisture in the air. When in clouds at four miles high, I heard a railway train; but when clouds were far below, no sound ever reached the ear at this elevation. At the height of 10,000 feet the discharge of a gun has been heard;

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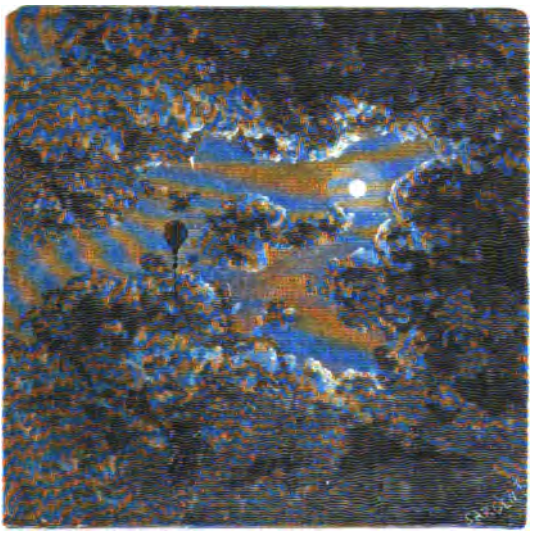
and I believe that a sound like thunder, which we heard when at a height of 20,000 feet above Birmingham, was due to the firing of some guns that were being proved there. The barking of a little dog has been heard at the height of two miles, whilst a multitude of people shouting has not been heard at 4,000 feet. So that some notes and sounds pass more readily through the air than others.

Such are some of the results derived from observations in balloons in England; but this country is of too small an area for such experiments. Wolverhampton was chosen for its central position, but in an hour or two we were always compelled to descend; whatever part of England we start from, in one hour we may be over the sea; and if we have been this time above the clouds, ignorant whether our motion has been small or at the rate of seventy or eighty miles an hour, we must penetrate them, and then our power is gone;—we have had to part with our ballast to ascend, and now we have parted with gas also; we cannot ascend again; and thus, whether our fears are groundless or no, the series of observations is limited.

Far better could the experiments be made in France, or on a large continent; and I earnestly trust that the country to which we owe the Balloon will utilize yet more her great invention for increase of knowledge; and it will be indeed strange if that generous and intelligent nation, which has placed so admirable an instrument at the disposal of the learned in all countries, for exploration of the higher regions, should be behindhand in its use.



"AFTER A TIME THE MOON SHONE WITH INCREASED BRIGHTNESS."

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THE RAINBOW.

CHAPTER IX.

THE HIGH REGIONS.

ABOVE the clouds the balloon occupies the centre of a vast hollow sphere, of which the lower portion is generally cut off by a horizontal plane. This section is in appearance a vast continent, often without intervals or breaks, and separating us completely from the earth. No isolated clouds hover above this plane. We seem to be citizens of the sky, separated from the earth by a barrier which seems impassable. We are free from all apprehension such as may exist when nothing separates us from the earth. We can suppose the laws of gravitation are for a time suspended, and in the upper world, to which we seem now to belong, the silence and quiet are so intense that peace and calm seem to reign alone.

Above our heads rises a noble roof—a vast dome of the deepest blue. In the east may perhaps be seen the tints of a rainbow on the point of vanishing; in the west the sun silvering the edges of broken clouds. Below these light vapours may rise a chain of mountains, the Alps of the sky, rearing themselves one above the other, mountain above mountain, till the highest peaks are coloured by the setting sun. Some of these compact masses look as if ravaged by avalanches, or rent by the irresistible movements of glaciers. Some clouds seem built up of quartz, or even diamonds; some, like immense cones, boldly rise

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upwards; others resemble pyramids whose sides are in rough outline. These scenes are so varied and so beautiful that we feel that we could remain for ever to wander above these boundless planes. But the sun, which still silvers the highest of these celestial mountains, begins already to decline.

We must quit these regions to approach the earth; our revolt against gravity has lasted long enough, we must now obey its laws again. As we descend, the summits of the silvery mountains approach us fast, and appear to ascend toward us: we are already entering deep valleys which seem as if about to swallow us up; but mountains, valleys, and glaciers all flee upward. We enter the clouds and soon see the earth; we must make the descent, and in a few minutes the balloon lies helpless and half empty on the ground.

I have said that the sky, as viewed from above the clouds, is of a deep blue colour, which deepens in intensity with increase of elevation regularly from the earth, if the sky be free from clouds, or with the increase of elevation above the clouds if they be present.

The sky, if seen through clouds, is of the same pale colour as seen from the earth, at whatever elevation the clouds may be; at the height of four miles, for instance, when we were still in cloud, the blueness of the sky was of the same pale colour as it is when seen from the earth.

When the sky is free from cloud, and but little water is present in the invisible shape of vapour, the colour deepens to an intense prussian blue at the highest elevation.

Speaking of the blueness of the sky, Sir David Brewster, in his paper "On the Polarization of the Atmosphere," observes: "We may conclude that 90° is, in the normal state of the atmosphere, the distance from the sun of the place of maximum polarization, and 45° the corresponding angle of incidence."

This determination of the place and angle of maximum polarization affords a highly probable explanation of the azure colour of the sky. Sir Isaac Newton regarded this colour as a blue of the first order, though very faint. Professor Clausius considers the vapours to be vesicles or bladders, and ascribes the blue colour of the first order to reflection from the thin pellicle of water.

In reference to these opinions the following facts are important:— 1. The azure colour of the sky, though resembling the blue of the first order when the sky is viewed from the earth's surface, becomes an exceedingly deep prussian blue as we ascend, and, when viewed from the height of six or seven miles, is a deep blue of the second or third order. 2. The maximum polarizing angle of the atmosphere,

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45°, is the same as that of air, and not that of water, which is 53°. 3. At the greatest height to which I have ascended, namely, at the height of five, six, and seven miles, where the blue is the brightest, the air is almost deprived of moisture. Hence it follows that the exceedingly deep prussian blue cannot be produced by vesicles of water, but must be caused by reflection from the air, whose polarizing angle is 45°. The faint blue which the sky exhibits at the earth's surface is, therefore, not the blue of the first order, but merely the blue of the second or third order rendered paler by the light reflected from the aqueous vapour in the lower regions of the atmosphere.

To appreciate all the beauty of cloud scenery when the air is loaded with moisture, an aërial voyage must be made on an autumn morning before sunrise, when the atmosphere is charged with the vapours of night.

The accidental circumstance of a late descent at night determined us to anchor the balloon and re-ascend before sunrise the following morning, and thus enable us to view the clouds under these conditions. It was towards the end of August, and we left the earth at half-past 4 o'clock A.M. The morning was dull, warm, and misty, and the sky was covered with cloud. The balloon bore us gently upward, making the first 1,000 feet in eight minutes: all below was thick mist, veiling the surface of the earth. At 3,500 feet, still gently rising, we entered a bed of cumulo-stratus. Fifteen minutes after we left the earth we had reached 5,000 feet, and then just emerged above the clouds. They, however, presently again formed all round and above the car, closing everything from view excepting only a line, bright as silver, which indicated the east. We were in a basin of cloud, whose sides extended far above us all round. We slowly rose, and when we reached its boundary the sun rose, flooding with light the whole extent of cloudland beyond, which glistened like a golden lake under his beams. The scene all round possessed a reality and grandeur far exceeding sunrise as viewed from the earth. Grouped around the car, both above and below, there were clouds of Alpine character, sloping to their bases in glistening light, or towering upwards in sheets of shining vapour, which added the charm of contrast to the splendid tints of sunrise. The clouds spread around us like an ocean, and, continually changing their forms, suddenly gathered themselves into mountain heaps and closed all round us, hiding the sun in neutral-tinted gloom; the earth was visible through breaks, and the early morning mists were seen creeping upon its surface as the daylight gathered strength.

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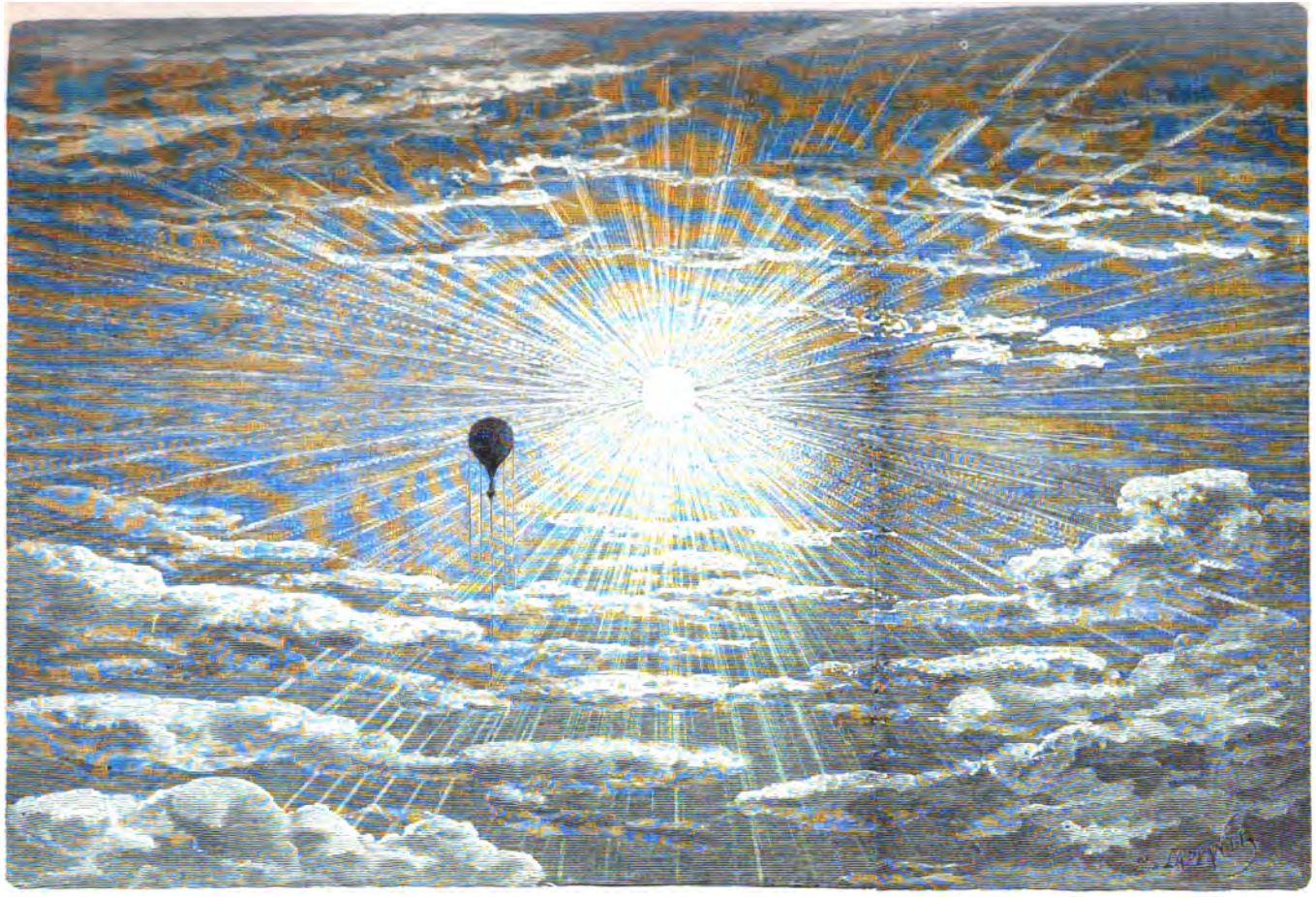

"THE SUN ROSE, FLOODING WITH LIGHT THE WHOLE EXTENT OF CLOUDLAND BEYOND."

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We threw out ballast, and, after rising through the noble valleys which formed and vanished so rapidly and in so fairy-like a manner, saw the sun as it were rise again, this time flooding the atmosphere with a brilliant sea of light; and as we rose higher and left the clouds far below, we looked down upon them bathed in a golden glow of the richest hue.

APPEARANCE OF THE EARTH VIEWED FROM A BALLOON.

All perception of comparative altitudes of objects on or near the ground is lost—houses, trees, the undulation of the country, &c., all are reduced to one level, and even the lower detached clouds appear to rest on the earth; everything, in fact, seems to be on the same level, and the whole has the appearance of a plane. Everything seen, looking downwards from a balloon, including the clouds, seems projected upon the one visible plane beneath.

Always, however great the height of the balloon, when I have seen the horizon it has roughly appeared to be on the level of the car—though of course the dip of the horizon is a very appreciable quantity—or the same height as the eye. From this one might infer that, could the earth be seen without a cloud or anything to obscure it, as that point of the plane beneath is directly under the eye, and the boundary line of the plane approximately the same height as the eye, the general appearance would be that of a slight concavity; but I have never seen any part of the surface of the earth other than as a plane. Towns and cities, when viewed from the balloon, are like models in motion. I shall always remember the ascent of the 9th October, 1863, when we passed over London about sunset. At the time when we were 7,000 feet high, and directly over London Bridge, the scene around was one that cannot probably be equalled in the world. We were still so low as not to have lost sight of the details of the spectacle which presented itself to our eyes; and with one glance the homes of 3,000,000 people could be seen, and so distinct was the view, that every large building was easily distinguishable. In fact, the whole of London was visible, and some parts most clearly. All round, the suburbs were also very distinct, with their lines of detached villas, imbedded as it were in a mass of shrubs; beyond, the country was like a garden, its fields, well marked, becoming smaller and smaller as the eye wandered farther and farther away. Again looking down, there was the Thames, throughout its whole length without the slightest mist, dotted over in its winding course with innumerable ships and steamboats, like moving toys. Gravesend was visible,

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also the mouth of the Thames and the coast around as far as Norfolk. The southern shore of the mouth of the Thames was not so clear, but the sea beyond was seen for many miles; when at a higher elevation, I looked for the coast of France, but was unable to see it. On looking round, the eye was arrested by the garden-like appearance of the county of Kent, till again London claimed yet more careful attention.

Smoke, thin and blue, was curling from it, and slowly moving away in beautiful curves, from all except one part, south of the Thames, where it was less blue and seemed more dense, till the cause became evident; it was mixed with mist rising from the ground, the southern limit of which was bounded by an even line, doubtless indicating the meeting of the subsoils of gravel and clay. The whole scene was surmounted by a canopy of blue, everywhere clear and free from cloud, except near the horizon, where a band of cumulus and stratus extended all round, forming a fitting boundary to such a glorious view.

As seen from the earth, the sunset this evening was described as fine, the air being clear and shadows sharply defined; but, as we rose to view it and its effects, the golden hues increased in intensity; their richness decreased as the distance from the sun increased, both right and left; but still as far as 90° from the sun, rose-coloured clouds extended. The remainder of the circle was completed, for the most part, by pure white cumulus of well-rounded and symmetrical forms.

I have seen London by night. I have crossed it during the day at the height of four miles. I have often admired the splendour of sky scenery, but never have I seen anything which surpassed this spectacle. The roar of the town heard at this elevation was a deep, rich, continuous sound—the voice of labour. At four miles above London, all was hushed; no sound reached our ears.

In conclusion, let us take the Balloon as we find it, and apply it to the uses of philosophy; let us make it subservient to the purposes of war, an instrument of legitimate strategy; or employ it to ascend to the verge of our lower atmosphere, and, as it is, the Balloon will claim its place among the most important of human inventions, even if it remain an isolated power, and should never become engrafted as the ruling principle of the mechanism we have yet to seek in the solution of the problem of aërial navigation.

The application of the Balloon, as an instrument of vertical exploration, presents itself to us under a variety of aspects, each of which is fertile in suggestion. If we regard the atmosphere as

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the great laboratory of changes which contain the germ of future discoveries, to belong to the chemist, the meteorologist, and the physicist, its relation to animal life at different heights, and the form of death which at certain elevations waits to accomplish its destruction; the effect of diminished pressure upon individuals similarly placed; the comparison of experiences in mountain ascents with the experiments in balloon ascents—are some of the questions which suggest themselves, and indicate the direction of inquiries which naturally ally themselves as objects of balloon investigations; sufficiently varied and important, they will be seen, to give the Balloon a place as a valuable aid to the uses of philosophy.

I should wish, before closing my own portion of this work, to express the gratification I feel that French gentlemen have united with me in collecting the results of other labours in scientific research, and I hope that my experiments may be of use in future inquiries. I most willingly place my experiences at the service of any aëronaut, and hope that the time is not distant when my experiments will be surpassed by others more extensive, and that the progress of aërial navigation may give a new scope to scientific research in the Balloon.

The voyages of MM. Flammarion, De Fonvielle, and Tissandier, which follow, have been translated from the French by T. L. Phipson, LL.D., &c.

CHARLES AND DE SAUSSURE.

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PART II.

TRAVELS OF M. C. FLAMMARION.

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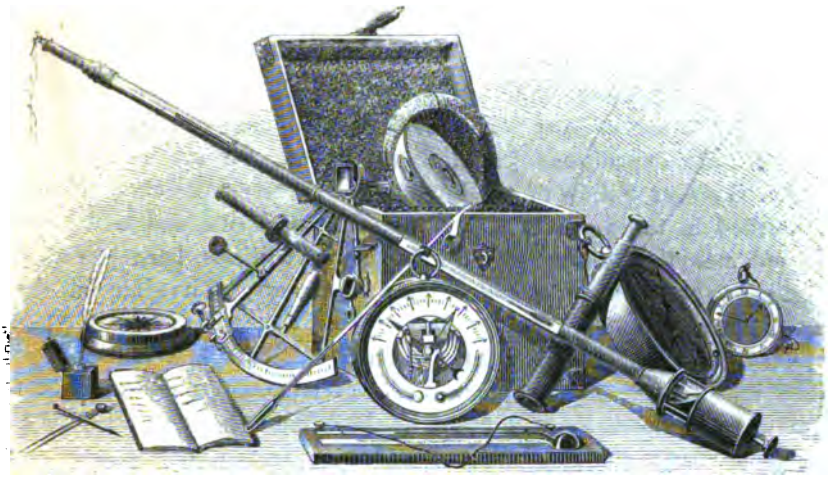

THE INSTRUMENTS

PRELIMINARY CHAPTER.

A SKETCH OF SCIENTIFIC BALLOONING FROM 1783 TO 1867.

No sooner had the brothers Montgolfier launched into the air their first aërostatic globe, no sooner had the art of aërial navigation dawned, than certain contemplative minds saw at once the immediate application of this noble physical conquest to the investigation of the vast atmospheric ocean at the bottom of which we live. This splendid and marvellous means of locomotion was at once hailed as an infallible method of obtaining a thorough knowledge of the earth's atmosphere; and though some were bold enough to believe, at this early date, that the course of a balloon might be directed at will, and that pleasure-trips to all parts of the world might be easily accomplished, others of more sober imagination looked only to the scientific applications of the new discovery. The illustrious Benjamin Franklin foresaw the meteorological importance of a balloon. Whilst passing through Paris he spoke to several members of the Academy of Sciences on the scientific future in store for aërostation. This future was then supposed to be near at hand; but even now, in the seventieth year of this century, who can say that we have realized it?

Before commencing the account of our aërial travels, we must point to the fact that such expeditions undertaken in the interests of science have hitherto been very rare, even in France, in spite of the well-

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recognized importance attached to those which were achieved at the beginning of the century. For the finest and most productive series of scientific expeditions into the atmosphere we are indebted to James Glaisher, Fellow of the Royal Society, the results of which are published in the volumes of the British Association, and will serve to enhance the interest of the French expeditions here recorded. But before we give an account of our own ascents, let us glance at the art of aërostation itself, and the discovery of Montgolfier.

On the 5th June, 1783, when Joseph Montgolfier and his brother, then managers of the old paper-works at Annonay, made their first public experiment in that town, philosophers all exclaimed with Lalande, "How simple a thing it is! How is it that this was not thought of before!" Truly, as Biot used to say, nothing is so simple as that which was done yesterday; nothing so difficult as that which is to be done to-morrow.

We cannot afford space to examine into the various accounts of flying mentioned in ancient mythology, in sacred and profane writing. Archytas of Tarentum flew a kite, it is said, 400 years B.C., and even manufactured a wooden pigeon which rose in the air for a few minutes. Simon the Magician made some attempts to fly from one house to another in the year 66, at Rome; and these experiments appear to have been renewed during the reign of the Emperor Manuel Comnenus, when a Saracen endeavoured to fly from the tower of the Hippodrome at Constantinople. In the 13th century, Roger Bacon had some notion of a "flying machine," whereby a man, upheld by the centre of his body, moved a system of wings by means of a handle. Towards the end of the 15th century J. B. Dante, a mathematician of Pérouse, rose above the Lake Trasimène, by means of artificial wings attached to his body. One day he fell on to the Church of Notre Dame and broke his leg; the same accident happened also to Oliver of Malmesbury, a learned English monk, who was very fond of such experiments. In 1638, Goldwin attempted to fly by means of wild geese trained for this purpose. Wilkins, in his fictitious account of a journey to the moon, proposed that vessels should be constructed and filled "with etherized air like fire," which would cause them to float upon air as boats float on water. Cyrano de Bergerac actually described five methods of rising in the air, one of which consisted in the use of a glass globe heated by the sun's rays; another very preposterous notion was that of throwing magnets into the air in such a manner as to draw up an iron cage in which the traveller sat! In 1670, Lana imagined that very thin copper globes, in which a vacuum would be produced, might rise in the air. In 1678, a mechanic of Maine, named

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C. FLAMMARION

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Besnier, constructed wings for his legs and arms, which, according to the *Journal des Savants* of that date, gave very satisfactory results.

A certain rope-dancer, named Allard, made similar experiments in the reign of Louis XIV., and was severely wounded in his descent from the high terrace at St. Germain, near Paris. It would appear that about 1710 Laurent de Gusman rose in the air upon the back of a wooden bird filled with air, if we must believe a singular engraving representing this event, and preserved in the *Bibliothèque Nationale*, at Paris. In 1772 the Abbé Desforges, Canon of Etampes, attempted an experiment by means of a boat provided with wings, but without the slightest result. In 1775, a certain M. de la Folie, of Rouen, endeavoured to construct a flying machine by combining certain kinds of electrical apparatus. A well-known novel-writer, Rétif de la Bretonne, has described, in his "Découverte Australe," the type of a flying man. At Paris, the Marquis de Bacqueville attempted one day to fly from a window of his house on the river, and fell ludicrously into the boat of a washerwoman on the opposite bank. Blanchard, who afterwards became celebrated by his aëronautical excursions, once tried a flying machine, and fared no better.

None of these attempts would ever have brought about the discovery of balloons. The scientific principle on which they are founded was exhibited at Edinburgh in 1767, by Dr. Black, Professor of Chemistry, who announced to his audience that a vessel filled with hydrogen gas would rise naturally into the air; it was tried in London in 1782, by Professor Cavallo, who filled soap bubbles with hydrogen gas, and saw them rise rapidly in the air on account of their specific lightness.

Montgolfier knew nothing of hydrogen gas when he made his first experiments. It was by means of heated air that he inflated the paper or linen globes of which his balloons were made, and thus gave them a specific lightness which caused them to rise to a certain height into the air. At 50° Fahr. air is 4 per cent. lighter than at 32°; at 122° its specific gravity is only 0·84, and at 212° only 0·72; air at 32° being taken as unity. But this is a very slight degree of dilatation, and we could not rise very high in a balloon expanded by warm air, even were this balloon of the enormous dimensions of the *Flesselles* of Lyons, whose diameter was 100 feet, and height 126 feet. As Montgolfier used heated air to cause his balloons to ascend, they were termed *Montgolfières*, or fire-balloons, and are essentially different from air-balloons (properly speaking, gas-balloons) or *aërostats*.

The discovery of balloons created much discussion in France, and nothing was more talked of in Paris than the marvellous boldness of

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the conception; for it was early foreseen that the day was not far distant when men would not be content with sending up their spheres empty into the regions of the clouds, but that they would soon wish to travel themselves into the highest strata of the atmosphere.

Professor Charles, afterwards a member of the Academy of Sciences, manufactured, in the month of August of that same year, a balloon which was inflated with hydrogen gas. On this occasion he got up a national subscription (the first of its kind) to defray expenses, and on the 27th August, at six o'clock in the evening, the *Globe*, as it was called, rose, from the Champ de Mars, high into the regions of space. Astronomers had taken up various positions in order to measure the height to which it rose; the discharge of a piece of artillery announced its departure, its entrance into the clouds, its reappearance above them, and its final disappearance. This public lesson of natural philosophy was deeply interesting to the numerous spectators assembled; they followed the *Globe* with their eyes as long as it could possibly be distinguished; and so great was the enthusiasm at this moment, that a torrent of rain which fell shortly afterwards was scarcely perceived, even by the most elegantly dressed ladies among the crowd, as may be seen by referring to the published engravings which represent the scene.

This balloon fell at Gonesse, and terrified the peasantry to such a degree that it was destroyed by them on the spot, torn into a thousand fragments, and the shreds dispersed in the country. At the invitation of King Louis XVI., Montgolfier sent up a fire-balloon at Versailles on the 19th September. It carried a car, in which were placed a sheep, a cock, and a duck, and these passengers were safely landed near the forest of Vaucresson, a short distance from their starting-point.

But all this was merely the prelude to aërial navigation. The well-known Pilâtre de Rozier astonished both the Court and the town by his offer to make an ascent in an ordinary fire-balloon. In fact, on the 21st October of the same year, this bold adventurer, accompanied by his friend the Marquis d'Arlandes, actually rose from the Château de la Muette in the car of a magnificent Montgolfier, and after passing over the capital, to the astonishment of the whole of Paris, they descended in the country near the Butte aux Cailles. This bold experiment opened out a new path, which was not long untrodden. On the 15th December MM. Charles and Robert left the grounds of the Palace of the Tuileries in a balloon inflated with hydrogen gas, and in presence of 600,000 spectators. The weather was extremely fine, and after a trip of two hours they descended at a distance of nine leagues from Paris, near Taverny, at

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Nèsles. In 1783 we remark that there were four aërial excursions, but in 1784 there were no less than fifty-two. Among these were the expeditions of Montgolfier himself at Lyons, of Guyton de Morveau at Dijon, the Duc de Chartres (father of Louis Philippe) at St. Cloud, and of Prince Charles de Lignes at Lyons.

Since then a considerable number of balloon ascents have been accomplished. Numbers of aëronauts have confided themselves to the sphere of gas, or to the flame of a fire-balloon; 3,500 ascents have been executed in Europe and America, and fifteen deaths only have been recorded. Of this number of ascents, however, a few only were undertaken for scientific purposes; most of them were merely for the sake of public amusement.

The first and most useful application of balloons appeared to be their adaptation to meteorological investigations. Aërostation, indeed, offered itself spontaneously to observing minds as a means of locomotion which might rival the ancient Pegasus, and carry the bold investigators into regions which no mortal eye had hitherto contemplated. This marvellous world of air, so mild and yet so strong, where tempests, whirlwinds, snow, and hail are elaborated, was henceforth opened to the inhabitants of the terrestrial soil. Its secrets would be disclosed, the movements of the atmospheric world would be counted, measured, and determined as scrupulously as astronomers can determine those of celestial bodies; and man, once placed in possession of this terrestrial mechanism, would be able to predict rains and storms, drought and heat, luxuriant crops and famines, as surely as he can predict eclipses, and thus ensure an ever-smiling and fertile soil!

Such was the magnificent dream evoked by the sight of the first balloon which carried its adventurous travellers into the higher regions of the atmosphere. The dream would have been realized ere this had the *mind* which created it directed human affairs. But, unfortunately, wisdom does not always guide us in our undertakings; false pride and misdirected ambition ofttimes predominate over these purer aspirations of the soul, and personal interest pulls us from the straightforward path which leads to the interests of all. What a period succeeded in France to the brilliant experimental era of 1784, which appeared to have given us such immense advantages! The era of the year '93! Then that of the 18th of Brumaire!

The year 1789 had scarcely spread its luminous and powerful wings of thought and experiment when the hydra of inferior instincts trod them under foot, and upon these intellectual ruins a hero of the sword raised the decrepit and false glory of war! . . . . .

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The same human imperfections, the same personal ambition and intrigue, have operated to the present day, so that the mind cannot develop itself in freedom. Progress is certainly made, but how slowly! It is opposed by the contemporary politics of the whole of Europe. Why are not the hearts of men united as a single organ? Why do they not beat with the same rhythm in the interests of the good and the beautiful? In France alone 250 times as much money is spent in the art of destroying the human species as is expended on education and science. This is why the projects and experiments of honest men remain so long in the state of dreams.

Instead of being directed to meteorological studies, as it should have been, aërostation has hitherto been chiefly applied to satisfy public curiosity, and as a source of amusement. Ever since the absurd ceremonies of the French Republic, ever since the ascent which took place at the coronation of 1804, when the balloon left Paris on the evening of the 16th December, and fell near the Campagna at Rome next morning, informing the Romans by its inscription that Napoleon had been crowned by Pius VII.; ever since the recalling of Louis XVIII. on the 3rd of May, 1814, celebrated by the most numerous ascents of balloons ever witnessed, no public entertainment has been considered quite complete without its balloon ascent. Smaller gaieties go off with a little fire-balloon, but the larger ceremonies require a real air-balloon and an aëronaut in flesh and bones.

Though scientific ascents have been somewhat rare, they have nevertheless been applied to solve such important problems that they occupy a very honourable position in the annals of science, whilst thousands of public balloon ascents are already consigned to oblivion.

The first ascent for the purposes of science was that made by Robertson and Lhoëst on the 18th of July, 1803. On referring to the report of it addressed to the Academy of Sciences of St. Petersburg, we find that they left Hamburg at nine o'clock in the morning, remained five and a half hours in the air, and came down near Hanover, at about seventy five miles from their starting-point. The balloon rose to 23,526 feet; the thermometer fell to 19°·6, whilst it was 68° on the ground. Eight experiments were made on the journey. The first had for its object frictional electricity. It was proved that at the altitude mentioned, glass, sulphur, and wax do not become electric by friction to any appreciable extent. The second experiment concerned voltaic electricity. A voltaic battery of sixty couples, silver-zinc, only produced five-sixths of the action upon the electrometer, which it was found to produce at the surface of the earth. The third experiment showed that the oscillation of a dipping needle

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increased with the height. The fourth experiment was applied to sound. By exploding ten grains of chlorate of potash, merely a sharp crack was heard; sound was found to be less powerful and less easily propagated than at the surface of the ground. In the fifth experiment it was sought to ascertain the degree of temperature at which water would boil at this height in the air; but by an unaccountable mistake, reminding us of Newton, who put his watch into the hot water and held the egg in his hand, Robertson plunged the thermometer into the fire instead of the water, and so broke it. However, it was quite possible at this great height to hold one's hand in the *boiling* water without experiencing the slightest inconvenience. In the sixth experiment the odour of a drop of sulphuric ether was noted. When it had evaporated for four seconds, it produced a painful, but useful, sensation in the nostrils; and smelling-salts are recommended by the authors to overcome a feeling of faintness or sleepiness that may come on in a balloon.

Drowsiness, in this instance, quite overcame the experimenters. Robertson made great efforts to swallow a piece of bread, but in vain. Of the two birds taken up in a cage, one was dead; the second had swooned away, and when it was roused and placed on the edge of the car, it moved its wings without stirring from the place, and at last fell heavily down through the air: this was the seventh experiment. The eighth consisted in noting that the sky above them was of a dark grey colour, and that the sun's heat was very slight, except in the inside of the car, where it made itself felt a little.

A second voyage was made on the 14th of August, 1803, and resulted in the belief that the *proportion* of oxygen gas contained in the air diminished notably as the higher regions were gained. Later ascents have shown that the supposition was erroneous.

The Academy of Sciences of St. Petersburg resolved to have the experiments of the Hamburg expedition repeated, and to engage for that purpose the services of Mr. Robertson himself, who was to be accompanied by one of the members of the Academy, Herr Sacharoff, a distinguished chemist and physicist. This new ascent took place on the 30th of June, 1804. The aëronauts left St. Petersburg at 7h. 45m. in the evening, and reached ground again at 10h. 45m. near Sivoritz, a distance of some sixty miles. At the surface of the earth the barometer marked 30 inches at the moment of departure, and the thermometer stood at 74¾° Fahrenheit; at the highest point which they reached, these two instruments marked respectively 22 inches and 42°·1. It was concluded from these observations that the balloon had ascended to a height of 8,868 feet. It was found to be impossible on

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this occasion to make any regular magnetic observations, but both Robertson and Sacharoff believed that the declination needle had ceased to be horizontal, and that its north pole had risen about 10° whilst they were in the air.

At the commencement of 1804, Laplace proposed to the members of the French Academy of Sciences, that advantage should be taken of balloons for solving certain physical problems, and notably that of magnetic intensity at great heights, as De Saussure had already remarked a diminution of magnetic intensity whilst making observations on the Col du Géant. He added that, as the Government had placed funds at their disposal for the prosecution of useful experiments, he thought that they might be applied to these kinds of researches. Berthollet and several other members who had also certain experiments on the atmosphere to propose, seconded the resolution; and this occurred at a very favourable period, for Chaptal, the distinguished chemist, was then Minister of the Interior. It was soon decided that Biot and Gay-Lussac, then two of the youngest and most ardent professors, should make the first experimental ascent.

The first ascent of these two young philosophers was to take place from the Jardin du Luxembourg, but the arrangements having failed there, they rose from the Conservatoire des Arts et Métiers, on the 24th of August, 1804. At the height of 13,124 feet they endeavoured, by means of a horizontal needle, to determine the magnetic intensity—this was, in fact, the chief object of their ascent, but the rotatory motion of the balloon presented an unexpected obstacle to these observations; the experiments were postponed in consequence until the next ascent, which was made by Gay-Lussac alone. He left the Conservatoire on the 16th of September, 1804, at 9h. 40m. in the morning, and descended again at 3h. 45m. in the afternoon, between Rouen and Dieppe, near the hamlet of Saint-Gourgon, having drifted 120 miles from Paris.

Having supplied his balloon with long hanging ropes, destined to counteract the rotatory or spinning motion, the clever observer was enabled to make some experiments with an oscillating magnetic needle, and obtained as a result that the mean duration of ten oscillations at all heights was forty-two seconds. He concluded from this that the magnetic power does not undergo any notable change even at the greatest heights to which we can have access. Gay-Lussac has expressed himself on this point in the following terms:—"The consequence drawn from my experiments may appear somewhat abrupt to those who recollect that I could make no observations on the inclination of the magnetic needle; but if we call to mind that the force

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which causes the horizontal needle to oscillate is necessarily dependent upon the intensity and the direction of the magnetic force itself, and that it is represented by the cosine of the angle of inclination of the latter force, we cannot help concluding that the horizontal force has not varied, or the magnetic force either."

This conclusion was quite legitimate at this period, when it was generally unknown that the duration of the oscillation of a magnetic needle is influenced by the temperature of the latter. Now, in Gay-Lussac's ascent the cold was intense enough to have produced a notable effect upon his needle. Moreover, in 1804 physical instruments were far from being so perfect as they are at the present day, and it was perhaps impossible to arrive at a rigorous solution of the problem. Even at the present day the problem is not solved.

The principal result obtained in this aëronautic expedition made by Gay-Lussac relates to the composition of the air, which he found to be constant even at the great altitude of 22,966 feet. He was the first person who brought down air collected at this enormous height, and had it carefully analysed. The result of this analysis has since been accurately confirmed by every subsequent experiment on this subject that has been made during the last fifty years.

Another no less important fact was the great difference found by Gay-Lussac between the temperature at the earth's surface and that of the higher regions which he reached. When he started, the barometer stood at 30·13 inches, and the thermometer at 82° Fahr. At the highest point reached by the balloon the barometer was found to have sunk to 12·94 inches, and the thermometer stood at 14°·9 Fahr. At this moment it is evident that Gay-Lussac must have been at an elevation of at least 23,000 feet above the level of the sea, and in rising to this height he experienced the effects of a difference of 67 Fahrenheit degrees of temperature.

From 1804 to 1850 we have no record of scientific expeditions in balloons. In the latter year MM. Barral and Bixio made two ascents for the purpose of investigating certain atmospheric phenomena still imperfectly understood. They wished to determine the laws which govern the decrease of temperature and humidity with height; they also desired to examine the composition of the air at various elevations, and its contents with regard to the amount of carbonic acid present; to compare the heating effects of the solar rays in the highest regions of the atmosphere with those observed at the surface of the earth; to discover whether a given point receives the same quantity of heat rays from every part of space; and to ascertain whether the light which is reflected by and transmitted through the

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clouds is polarized or not; and also to decide several other questions of an interesting character.

Everything having been got ready for their departure from the garden of the Paris Observatory, they ascended on the 29th June, 1850, at twenty-seven minutes past ten o'clock in the morning. The balloon was inflated with pure hydrogen gas, obtained by the action of hydrochloric acid upon iron.

It appears, according to the calculations, that these two observers must have risen to a height exceeding 30,000 feet.

Soon after they had started it was found that their balloon was not in perfect order. Having weathered a severe gale, it had got torn in several places, and, at the last moment, had been mended somewhat hastily. A heavy rain was falling at the time of departure. What was to be done? The wind was so violent that MM. Barral and Bixio rose into the air without even determining beforehand the ascensional power of the balloon, which is usually done by means of a kind of steel-yard. They rose with extreme rapidity, like an arrow from the bow, according to the spectators assembled, and soon disappeared among the clouds.

But the balloon, becoming rapidly inflated and pressing upon the network, which was far too small, bulged out at top and bottom, and pressed down upon the two aëronauts, the car being suspended by ropes which were much too short; in fact, it soon covered them like an immense hood. Their position was most critical, and when one of them endeavoured to secure the valve-rope, a rent was made in the lower part of the balloon, and the hydrogen gas, which escaped from it close to their faces, suffocated both of them, causing a momentary exhaustion, followed by nausea and violent vomiting.

A glance at the barometer showed that they were descending rapidly; and seeking to explain this unexpected occurrence, they found that the balloon was split open about the middle, and that the rent was upwards of two yards in extent. It was then evident that all they could hope for was to escape with their lives from this most perilous ascent. The unfortunate physicists threw overboard all their ballast, and everything else that they could get rid of, even their wearing apparel and their fur coats, only excepting their instruments.

At last they touched the ground at a quarter-past eleven, in a vine-yard at Dampmart, near Lagny. The labourers and peasants who ran to their assistance found them holding on to the vine stumps to arrest the horizontal drifting of the car over the ground.

An aërial expedition under such circumstances could scarcely be expected to prove of much use to science. Arago reported upon it to

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the Academy; but neither the preparations for this journey nor for that of Biot and Gay-Lussac were carefully enough prepared to be of service in collecting scientific observations.

Barral and Bixio determined to ascend again without delay; they did so a month later from the Observatory, and Arago witnessed this ascent, as he had done that which we have just described. He did everything in his power to make this second ascent as fruitful as possible in a scientific point of view. They started on the 27th July, which was also a wet day.

A very interesting optical phenomenon was noticed on this occasion. Before rising to the highest point, the layers of cloud which surrounded the balloon on all sides became very much less dense, and the disc of the sun was seen through them pale and faint; at the same time there appeared below the horizontal plane level with the car of the balloon, and at an angular distance from this plane equal to that which measured the apparent height of the sun, a second sun, appearing like the reflection of the first from a sheet of water. It appears probable that this second image was due to the reflection of the sun's rays from the horizontal planes of crystals of ice floating in this vapory atmosphere.

But let us refer at once to the most extraordinary result yielded by the thermometrical observations. Gay-Lussac, as we have just seen, noted a degree of cold represented by 15° Fahrenheit when he had risen to a height of 23,000 feet. This low temperature was experienced by MM. Barral and Bixio, whilst enveloped in a cloud at an elevation of about 19,685 feet; but from this point to a distance upwards of some 1,969 feet, the temperature varied in a most singular and unexpected manner. At a little distance above the higher surface of the cloud, when at an altitude of 23,127 feet, their thermometer sank to minus 38°·2 Fahr., which is 54° below the temperature noted by Gay-Lussac at the same altitude.

This curious fact has been commented upon at various times, but no positive explanation of it has yet been supplied to us. The observation requires confirmation. Science knows little or nothing yet of what is going on in these higher regions of the atmosphere.

The scientific observations which were to have been made during this ascent have been alluded to above; they have contributed somewhat to the study of Meteorology. We will give the following interesting extract from the note-book of the two learned aëronauts:—

"The balloon is that of M. Dupuis-Delcourt, in which we made our first ascent; its capacity is about 23,000 cubic feet. It has a lower

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orifice, constantly open, for the escape of gas in case of dilatation. The car is suspended at about thirteen feet below this orifice, which is situated at the extremity of a long tail-like appendage some twenty-two feet long; so that the fully inflated balloon is situated at least thirty-six feet from the car, and cannot therefore interfere with the making or recording of observations. The instruments are fixed, at a convenient distance from the observers, around a thick band of sheet-iron attached to the usual balloon circle, which is of wood, and to which the ropes of the car are attached.

"The body of the balloon being so far distant from the car, the latter oscillated at first very much from side to side, owing to the action of the wind upon the aërostat, and it was only after a long series of oscillations to and fro that we found ourselves at last vertically suspended beneath our balloon. On rising we struck against a tree and against a mast, by which a barometer and a thermometer were broken, and the former thrown out of the car.

"4h. 3m.—*Departure.*—The balloon rises very slowly and moved towards the east; we throw out a few pounds of ballast and rise quicker. The sky is quite overcast. We soon find ourselves in a slight fog.

Time.	Barometer.	Thermometer.	Height.
h. m. s.	Inches.	Deg. Fahr.	Feet.
4 6 0	27·35	60·8	2,484
4 8 0	26·57	—	3,278
4 9 30	25·81	55·4	4,081
4 11 0	25·07	49·6	4,866

"Above us a sheet of cloud is spread; below we see here and there isolated clouds, which appear to be rolling towards Paris. We feel a very fresh breeze.

Time.	Barometer.	Thermometer.	Height.
h. m.	Inches.	Deg. Fahr.	Feet.
4 13	23·53	48·4	6,604
4 15	22·00	—	8,422
4 20	19·00	31·1	12,306

"The cloud into which we now enter has the appearance of a very thick fog; we no longer see the earth.

Barometer	Thermometer.	Height.
Inches.	Deg. Fahr.	Feet.
15·96	19·4	16,801

"A few rays of sunshine gleam through the clouds. The barometer is oscillating between 14·45 and 15·22 inches; the thermometer marks 48°·2; calculation gives us for our height 19,393 to 18,019 feet.

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"The balloon is fully inflated; the tail part, which hitherto has been quite flattened by the pressure of the atmosphere, is now distended, and from its orifice the gas escapes in the form of a thin white stream: we perceive its odour very distinctly. We see that there is a rent in the balloon about a yard and a half from the top part of the appendage. This opening allows the gas to escape more freely, and as it exists at the lower portion of the balloon it can only slightly diminish our ascensional force.

"We are quite covered with small crystals of ice, in the form of extremely minute needles, which lodge in the folds of our clothes. When the balloon rises a little, which we see by a fall of the barometer, our note-book catches these ice needles in great quantities, and they appear to fall upon it with a slight cracking sound. Nothing similar is noticed whilst the balloon sinks a little.

"We open the cage containing two pigeons; they refuse to fly off. We throw them into the air; they spread their wings and fall heavily, turning round and round in wide circles, and soon disappear in the fog which surrounds us. We cannot see the grapnel, which is hung down beneath the car of the balloon at the end of a rope 164 feet long.

"4h. 32m.—We throw out some ballast, and rise somewhat higher. The clouds clear above us, and we see the blue sky, such as we see it from the earth on a fine day."

As regards the great degree of cold experienced in this expedition, and the little crystals of ice, Arago says: "This discovery explains how these minute crystals may become the nucleus of large hailstones; for they may condense around them the aqueous vapour contained in that portion of the atmosphere where they exist. They go far also to prove the truth of Mariotte's theory, according to which these crystals of ice suspended in the air are the cause of halos, parhelia or mock-suns, and mock-moons. Moreover, the great extent of so cold a cloud explains very satisfactorily the sudden changes of temperature which occur in our climates. By discussing the meteorological observations made in Europe the day before, the day after, and on the same day on which they made their memorable ascent, MM. Barral and Bixio have shown that certain cases of general and sudden cold took place, which were certainly connected with the existence of very cold clouds travelling from the north-east towards the south-west."

Two years after this ascent the committee of Kew Observatory resolved that a series of aëronautic expeditions should be made, with the view of studying the meteorological and physical phenomena

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which occur in the highest regions of the terrestrial atmosphere. The resolution was adopted by the Council of the British Association.

Mr. Glaisher has given above a detailed account of some of these ascents, and I shall, therefore, not return to the subject by continuing this retrospective review any further, but shall at once proceed with an account of my own expeditions.

I do not wish to prolong this preliminary chapter by stating the motives which induced me to make these aërial voyages, but I cannot remain quite silent on this head.

During the year 1858, whilst in the Luxembourg Gardens, a balloon passed overhead at a very slight distance from the ground. I could not only distinguish the persons in the car, but heard them speak. The weather was extremely fine, the sky of a beautiful pure blue, and the aërial skiff glided silently along, leaving no trace behind. Young, and full of ardour for discovery and adventure, like most people of sixteen years of age, I would have given the world to be in the car of that balloon; and long afterwards I could think of nothing but a journey into the atmosphere. However, my attention being constantly directed to astronomy, I was compelled to forget this temporary exhibition that had struck me so forcibly and so suddenly.

A few years ago, having turned my attention to the investigation of the laws which govern the phenomena of the atmosphere, to the comparison of the succession of seasons on our globe and on other planets of the solar system, to the physical constitution of the atmosphere as regards radiation of light and heat, the similarity of aërial and marine currents, &c., I again felt a strong desire to embark into the mysterious regions of the air, whose effect upon the life and beauty of the earth is evidently so great. I was not a little surprised, also, to find a marked difference between the science of astronomy and that of meteorology. Is it not singular, in fact, that the progress of the former has been so great that we are enabled by its aid to calculate with the utmost degree of certainty the time at which eclipses will occur, one century, two or ten centuries beforehand, and what stars will be visible above any given horizon at any future period; the positions that will be occupied at such and such a time by the satellites of Jupiter, or the relative positions of double stars, &c., whilst we can scarcely assert with probability what kind of weather we shall have to-morrow? The history of science tells us, however, that meteorological investigations have never been carried on with that energy and care which has long characterized the science of astronomy. They have never been prosecuted on so large a scale; and as to aërostation, it has only been practised at rare intervals by the few enlightened

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men whose labours we have just reviewed. It would seem, indeed, to use the expression of a well-known astronomer, that philosophers had feared to trust themselves to a balloon. How can that be? Surely we have no safer or more agreeable means of locomotion! At all events, everyone does not appear to be convinced of it, for a gallant field-marshal, who has never hesitated to advance through the discharge of cannon and musketry on the field of battle, has declared to me more than once that he would not, for a whole empire, ascend even in a captive balloon!

THE SUN REFLECTED BY THE CLOUDS.

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THE ADIEU.

CHAPTER II.

MY FIRST AËRIAL VOYAGE.

ASCENSION DAY, 1867.

"Où va-t-il ce navire? Il va, de jour vêtu,
A l'avenir divin et pur, à la vertu,
A la science qu'on voit luire,
A l'amour sur les cœurs serrant son doux lien,
Au juste, au grand, au bon, au beau...Vous voyez bien
Qu'en effet il monte aux étoiles!"

VICTOR HUGO.

EVERY motion which occurs in our atmosphere is governed by a fixed law. The forces which come into action to form winds, clouds, and tempests, the forces which preside at the grouping of storms, the birth of soft breezes, the movements of the aërial tides, are just as positive and absolute as those which cause the celestial orbs to revolve in the depths of infinite space. Man, so insignificant a creature when his material dimensions are compared with those of the universe, but so great in his spiritual nature, has discovered the causes of these celestial motions. But the movements of the atmosphere have hitherto escaped his observation and still refuse to conform to his calculations. We may assert, nevertheless, as natural philosophy has long taught, that not even the slightest breath of air is the product of chance, and we may confidently hope to see the day when the causes of the

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slightest motion shall be known, and when the predictions of weather will be the result of a true meteorological science worthy of comparison with her eldest sister Astronomy.

The most direct and natural means of observing atmospheric currents appears to be that supplied by aërostation. In order to become perfectly acquainted with diurnal variation of climate at various heights, in order to examine thoroughly into the nature and formation of storms, it seems most rational to "go and see" what is being done in these higher regions, and to come face to face with the facts themselves, A long accumulation of *facts* and their systematic discussion will solve these problems better than any hypothesis, however ingenious.

Another point of interest connected with the currents of the atmosphere is this, that were their variations at different heights known for the different hours of the day and the seasons of the year, the great problem of aërial navigation would be almost completely realized.

I therefore undertook a series of aërostatic experiments with the view of observing these currents, and at the same time taking those physical observations which can only be made in a balloon, such as the temperature of the various strata of air, their electricity, their influence on the magnet, the moisture of the atmosphere, solar radiation, meteoric phenomena, the forms of clouds, the colour of the sky, the scintillation of the stars, the chemical composition of the air at various altitudes, the laws of sight and sound in these high regions, &c.

The programme of these experiments was traced out by Arago at the time when Barral and Bixio made their ascents, and the subjects for special study were determined on after perusing the results obtained by Gay-Lussac, Robertson, Welsh, and Glaisher. The instruments employed were constructed by M. Secrétan, Optician to the Paris Observatory.

My first expeditions were undertaken for the Société Aërostatique, and the Government kindly placed at my disposal the fine balloon made for his Majesty Napoleon III. at the time of the Italian war in 1859, which had never been used, for it arrived at Solferino the day after the victory. Its silk envelope is double and nearly impermeable: this fact, conjointly with its great capacity, about 800 cubic metres, rendered it most valuable for scientific research and also for long journeys in the air.

The purely scientific observations which I have been able to make in these balloon ascents have formed the subject of special papers, and have also been published in a condensed form in a note read at the Academy of Sciences. The principal results will be given in the

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present work; but there is, moreover, an interesting popular element connected with the novel impressions and sensations spontaneously experienced in these ascents, which I must place before the reader as our narrative proceeds.

Before the Departure.—We visited the room in which the empty balloon was lying as an immense tissue of varnished silk spread over the floor. An enormous network enveloped it everywhere: it presented, on the whole, the appearance of an amorphous mass of very little interest to the eyes of the vulgar. But to the eye of an aëronaut it appears in quite another character; and he can scarcely refrain from addressing it in some such terms as these: "Inert and formless thing, that I can now trample under my feet, that I can tear with my hands, here stretched dead upon the ground—my perfect slave—I am about to give thee life that thou mayest become my sovereign! In the height of my generosity I shall make thee even greater than myself. O vile and powerless thing! I shall abandon myself to thy majesty, O creature of my own hands! and thou shalt carry me beyond my kingdom into thy own element, which I have created for thee; thou shalt fly off to the regions of storms and tempests, and I shall be forced to follow thee! I shall become thy plaything; thou shalt do what thou wilt with me, and forget that I gave thee life. . . . Perchance thou wilt deprive me of my existence, and leave my corpse floating in the hurricane above, until thy perfidy, fatigued by its own exertions, shall fall like a blind monster in some desert place, or into the foaming waves which shall swallow us up together!"

Soon indeed did this inert, amorphous object become a thing of power, a special being, ready under the influence of the gas which gradually inflated it, to fly off into its own element, and awaiting only the ominous words, "let go."

The Departure.—M. Eugène Godard, "Aëronaut to the Emperor," had the management of the balloon. A lively companion, Count Xavier Branicki, took his seat in the car opposite to me. The motion of the balloon prevented the proper arrangements of my instruments and apparatus. "It shall be done up above," I said, "when the impatience of the bounding and swinging aërostat will be satisfied and remain quiet."

These first ascents were made from the Hippodrome. The choice of this locality was criticised as not being a proper place for the starting-point of a scientific expedition; but, after all, the starting-point has little to do with it—the great thing is to get up into the air in the best condition you can; and the manager of the Hippodrome facilitated our journey very much by placing at our disposal the wide space used

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for balloon ascents and the large gaspipe constructed for the express purpose of inflating balloons as rapidly as possible. Later, I had the opportunity of starting as Gay-Lussac had done, from the garden of the Conservatoire des Arts et Métiers.

Wherever the starting-point happens to be, the moment of departure itself has something very solemn about it. In the midst of friends who have come to witness your first ascent, and whose eyes anxiously follow all your movements, you rise majestically into the air. The motion by which you ascend is not felt in the least; you know you are rising, for the panorama of Paris gradually spreads itself out beneath, and you can soon see it entirely, together with the surrounding green suburbs and country.

"*Is not this fine!*" was the first exclamation that escaped our lips. No description can convey the impression produced by such a magnificent panorama. Those who have endeavoured to describe it have fallen into a naïve and ridiculous style of writing. The grandest and most sublime view seen from the summit of a high mountain on an exceedingly bright day bears no comparison to the beauty of nature as seen perpendicularly from the regions of space. Thus only can we perceive the beauty and grandeur of nature in all its sublimity, and that creation is one immense expression of harmony.

The first impression made by such an ascent is a novel sensation of well-being or contentment, to which is added the vain little pleasure of feeling yourself soaring much above the level of other mortals, and at the same time of contemplating such an exquisite scene. As to the motion of the balloon, it is impossible to feel it. (An aëronaut should be careful before starting to balance his car properly; he should also balance the ascending power of his balloon sufficiently to rise as slowly as possible, not like an arrow shot from the bow, which not only destroys the charm of the view, but does not give the physical instruments sufficient time to acquire the temperature of the atmospheric strata through which they pass.) We cannot, as I have just said, feel that the balloon rises. *The earth appears to descend* beneath us; the group formed by our friends below becomes smaller and smaller, and their shouts of adieu reach our ears more and more faintly; soon they are mixed up in the general uproar of the town, which predominates over every other sound. The populous city of Paris spreads out beneath us, its thousands of roofs, its domes and cupolas, its gardens, boulevards, and its surrounding landscape; it is a spectacle which equals anything described in the "Arabian Nights."

The works of man are soon reduced to nothing in such a vision. The grandest palaces, the highest monuments, towns which have

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withstood the storms of centuries, all are levelled to the ground. Notre Dame, the Arc de Triomphe, the Louvre, which excite such universal admiration when seen upon earth, are all as nought when viewed from the regions of the sky. The whole town of Paris is reduced, after a little while, to the size of one of those maps in relief which we see at the Museum of the Invalides. Seen from above, the perspective of the town is entirely modified; the long avenues and large groves are reduced to small cottages and little gardens. The river Seine appears as a narrow grey ribbon along the landscape; the great palace in the Champ de Mars appears very like a little white rolly pudding! Beyond the Louvre the tower of St. Germain l'Auxerrois, flanked by the church of the Mairie, was not unlike a small coal-pit. At first the column of the Place Vendôme and that of the Bastille appeared wider above than below, but as we mounted higher all the statues and columns were levelled to the ground—pointing to the fact that glory is, after all, equal to nothing! How everything is changed as seen from a great height!

To the north-east our view extended to Meaux, but we recognized neither mountains nor valleys; the earth appeared as one immense plane richly decorated with ever-varied colours, like a beautiful miniature. The first impression which predominates is that of perfect *immobility;* the next is caused by the unexpected magnificence of the view spread out beneath us. To these a third is soon added in the shape of a doubt as to the perfect security of the balloon. The thoughts of the vast abyss beneath cause us involuntarily to reflect upon the solidity of the aërial machine. If the gas were to escape above? if one of the ropes gave way? if the bottom of the car came out? suppose we could not cause the balloon to descend again? how if we were caught up in a storm or a waterspout? suppose we fell out? . . . But such fears soon give way to calm reflection; the balloon is as solid in the air as a rock upon the ground. So let us follow the aërial skiff on its voyage.

The Voyage.—We left the earth at twenty minutes past five, and in the space of ten minutes we were 1,969 feet high and 14,100 to the south-east of our starting-place. We were travelling at the rate of nearly twenty-one miles an hour. When passing over the Western Railway station, on the left bank of the river, a cloud hid Epinay from our sight. We distinctly heard the noise of the locomotives and other railway gear; a little further on we heard a military band playing. Every Parisian noise was audible, but the barking of dogs predominated over the general hum on the earth's surface.

At fifty-eight minutes past five we were considerably higher. The

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balloon being dilated by the warmth of the sun's rays, gas was escaping from the lower extremity, which is purposely left open. We were made aware of this escape by the odour of the gas, which is unmistakeable. At six o'clock we again crossed the Seine, above the point where the Marne falls into it.

Paris is now far away from us. We float over green plains, delicately shaded by the hand of Nature. The smallest objects are most perfectly defined. But a slight fog now spreads itself, like a transparent veil, over the surface of the country. This veil is thickest towards the west. Nature sings to us from beneath this thin gauze. Among other birds we distinguish the notes of the lark. The chirp of the mole-cricket and the croaking of frogs also mount into the air.

We are now drifting silently and slowly through the atmosphere, at the rate of a little more than eleven feet per second, or 722 feet per minute. We see the shadow of the balloon floating over the green fields and the woods. Later, our shadow gets further off as the sun declines, until the sun and the balloon being in the same horizontal plane, we have no shadow; later still, when the sun sinks below us, our shadow is cast above. Those who would wish to see their shadow no longer under their feet, but above their heads, must make an ascent in a balloon.

At twenty-seven minutes past six we pass over Valenton, whose regular parks appear as a marvel of draughtsmanship. The whole population of the place was out to gaze at us. We rise a little into a cooler stratum of air, and the velocity of our motion increases: we are now travelling at the rate of twenty feet per second.

A vegetable hygrometer, which I had constructed in the morning, and fixed to a square foot of white cardboard, slipped out of my hands and fell over the car; I leaned out to catch it, but M. Godard prevented me, saying that it was highly imprudent to lean out of the car of a balloon suspended some thousand yards high in the air. I therefore contented myself with observing the fall of the small apparatus, and watched it for four minutes and fourteen seconds before it disappeared like a little sparkling star over the green forest of Sénart.

When above the railway station of Lieusaint, we throw out some ballast; but, as at first it descended less rapidly than the balloon, it afterwards fell upon us as a shower of sand. We believe that we see a very extensive storm in the distance, over the south-eastern horizon. The fine hills of Villeneuve-Saint-Georges, the slopes of Montgeron, the valley of Yères, are all passed over without our being able to distinguish any undulation in the immense plane.

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Some railway trains, which pass immediately underneath, signal us by a joyous whistle from the locomotive. We reply by waving our flags.

At fifty-four minutes past six our height is only 1,640 feet, and our motion thirty feet per second. The latter is becoming accelerated. At four minutes past seven, however, it is reduced to twenty-three feet per second. The little town of Melun is on our left, and the joyous shouts of the inhabitants salute us. At a quarter-past seven we cross the Seine once more, below Melun.

Thunder is heard growling beyond, and zigzag lightning flashes across that portion of the sky. Around us the sun shines brightly. We partake of a slight repast, and some generous Hungarian wine. The sun gilds our balloon with its evening rays, and the aërial skiff glides silently along.

I shout; the sound returns as an echo, after a lapse of six seconds. It would be interesting to ascertain whether the vertical velocity of sound is equal to its horizontal velocity in the air, and if the echo is really returned from the plane beneath. We shall speak of this further on. In the first expedition, I was much struck by the vague depth of the echo: it appears to rise from the horizon, and has a curious tone, as if it came from another world.

We pass over the forest of Fontainebleau: a deathlike stillness appears to pervade the whole of Nature. There would be absolute calm, were it not for the murmur of insects and birds which rise near us, and for the rolling of the thunder which has approached. Distant clouds roll towards us. But we appear to be without motion. If we shut our eyes, or fix our looks upon the sphere of gas above which carries us along, it is impossible to perceive any motion. Nevertheless, our velocity has increased. It is now nearly twenty-three miles an hour, or about thirty-three feet per second.

The storm, which we have remarked for some time, is evidently centred in the zone in which we are floating along. We appear to be drawn towards it: we approach like two trains about to meet. At half-past seven we have crossed the marshes and rocks of the forest, and we float over the valley of La Solle. We continue to approach the storm-clouds. The lightning and thunder are nearer to us. Beneath we have the forest and its dark landscape; from the bottom, the isolated fragments of rock dispersed among the trees produce a singular effect, and resemble not a little some of the mountains in the moon.

The storm drives upon us with a rapidity which we did not anticipate; in a few minutes we shall be enveloped by it. There is only

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Imp. Lemercier & Cie

A THUNDER-STORM ABOVE FONTAINEBLEAU.

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one or two things to be done: either to rise high above the storm-clouds, or to make a descent at once. The former is quite impossible, unless we are cruel enough to throw our noble companion into the forest, and so lighten the car.

The Descent.—Whilst we hesitate, the balloon enters upon the limits of the rain, and already large drops, which strike the aërostat with a slight cracking sound, cause it to descend to the tops of the oak trees. The wind roars through the foliage, and the highest branches bend before the tempest. The balloon skims over the trees at the rate of thirty-four feet per second, and the car is about to be precipitated on to the roofs of the houses at Fontainebleau, which appear to approach us with the strides of a giant. The tumult of a thousand voices breaks upon us. To accomplish a safe descent when surprised by wind and storm, requires not only remarkable coolness and presence of mind, but a sharp look-out, and a practical knowledge that can only be acquired by long experience.

I may add, that when scientific observations are to be carried on in a balloon, perfect confidence must be reposed in the strength of the aërial machine, and in the knowledge of the aëronaut who directs its movements; and perhaps I may be allowed to take this opportunity of stating that I found the one in the *Solferino* balloon, and the other in the practical experience of M. Eugène Godard, who, in less time than is required to write these lines, caused the balloon to sail right over the town, and to fall with a graceful curve into the adjacent park.

The cracking of the branches made us aware that we had touched the tops of the trees, and that the car of the balloon was making an entrance into the forest. But every moment we rebounded again into the air, springing some twelve yards at a time, and falling again upon the wood. The gigantic machine was soon exhausted, however, and it stopped like a being out of breath, upon the border of the avenue, when we prepared to set our feet again upon the ground.

We hoped to be able to keep the balloon inflated, by filling the car with large stones, and to continue our journey, as our noble companion intended to return to Paris. But the storm burst upon us with a torrent of rain, which continued until midnight, and transformed the streets of the town into a series of small rivers and lakes. By the aid of a numerous concourse of people, who ran to see us descend, we were enabled to secure our instruments, and to empty the balloon of its gas. Night had scarcely come upon us when we were received by the hospitable family of the late M. Goldschmidt, the talented and laborious astronomer who was lost to science a year before.

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We touched ground at a quarter to eight, having travelled here from Paris at the rate of an ordinary railway train. We had evidently been drawn towards the tempest by a species of attraction. The motion of different zones of air towards the point of lowest barometrical pressure is easily explained, and accounts for the general behaviour of cyclones and tempests. If, instead of descending, we had remained in the zone of the storm, in spite of the thunder and lightning which began to surround us, we should have stayed our course for a moment at Moret, and then we should have been carried back to Paris by the storm itself, where we should have arrived about nine o'clock. To be carried along thus on the wings of the lightning would be, doubtless, worthy of a man of science, but it would be prudent to ascertain beforehand whether the gas might not be influenced by the electric flash, and so precipitate us on to the plains below; or whether the tempest would only carry along bodies already struck by the lightning. In both cases the destiny of the aëronaut would be the same. But perhaps the balloon might escape, on account of the isolating material of which it is made. The experiment would be a fine one to try, but might result in most disagreeable consequences.

The feelings of an aëronaut during a balloon ascent are almost impossible to describe. To the contentment of finding oneself floating high above the miseries of mankind, is added the feeling of a strange and absolute calmness, such as is never experienced upon the earth. I myself never felt any giddiness, but my companion, Count Branicki, was affected by it from the moment we left the earth until we had passed over Villeneuve-Saint-Georges. There appears, however, to be something imaginary about this; for the very time that the Count should have experienced giddiness—that is, when he consented to look down upon the earth—the feeling left him. If the sides of the car had not rendered the thing quite impossible, our companion would certainly have allowed himself to be drawn down to the soil of France. I may add that, without having experienced this disease of vision, I also felt a vague desire to throw myself out of the balloon. Though feeling convinced that it would be certain death, I was under the influence of a mild temptation to allow myself to fall, and my death became for the moment a matter of indifference to me. But, happily to those who travel in balloons, it is a species of temptation which there is no difficulty in resisting. These sensations are, I hope, confined to aërial navigation.

A little drama, such as might interest the audience of a theatre, took place during our descent. In the middle of the tempest, our

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aëronaut, casting a rapid glance at the forest, suddenly took out of his bag an immense Spanish clasp-knife, which he attached to the network by a steel chain. What did this mean? Did he intend to sever the ropes, and so cut short our descent? Why was the knife brought out? This forms the serio-comic *dénouement* of the piece. The knife was destined, at precisely the proper moment, to cut the string which held together the coil of rope to which the anchor or grapnel is attached. It is fastened to the rigging, in case it should escape from the hand at this critical period. Eugène Godard is prudence itself personified, and is exceedingly clever in managing to procure a safe descent. More than once he has actually been able to cause the balloon to descend into a certain field into which he has called the peasantry who were on the look-out. This ascent which he made with me was his 904th excursion. The descent is, without doubt, the most dangerous moment of the expedition, but it is also a moment in which man feels some pride in his power over the elements.

Thus terminated my first journey in the air.

WE TOUCH THE TOPS OF THE TREES.

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LEAVING PARIS IN A BALLOON.

CHAPTER III.

MY SECOND VOYAGE, 9TH JUNE, 1867—DESCRIPTION OF THE BALLOON—CONDITIONS OF SECURITY REQUIRED FOR AN AËRIAL VOYAGE.

BEFORE proceeding with an account of this second journey into the atmosphere, it is requisite to say a few words upon the method employed to inflate the balloon, and on the principal precautions taken to ensure the aëronaut from danger during an ascent, and whilst he remains isolated in the air. The novel impressions produced by our first expedition have caused us to neglect these material details, which have, nevertheless, sufficient importance to deserve a rapid glance here.

The inflation of a balloon is usually done with carburetted hydrogen gas, or street gas, the mean density of which is about one-half that of air. Although much heavier than pure hydrogen, it is much easier to manage, and instead of being manufactured on the spot at great expense, like the latter, it is procured at once from some gasometer in the town or from a gaspipe. When an ascent is to be made from some scientific establishment, the gas may be got from the neighbouring pipes, and we need only take exactly the quantity requisite to inflate the aërostat. Such is the manner in which I managed the inflation at the garden of the Conservatoire. It is not only an expensive, but a very laborious undertaking to charge a balloon with pure hydrogen

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gas; it takes numerous carboys of sulphuric or hydrochloric acid, and many hundredweights of iron, to produce a sufficient volume of hydrogen gas. A series of connected vats or barrels must be filled with the acid diluted with water, and the gas conducted into a vat where it is washed; it must also be dried by passing it over quicklime, and cooled by a stream of water. After all these precautions it is conducted to the balloon by means of a long tube. Again, hydrogen is of all gases that which possesses *endosemosic* or permeating properties in the highest degree; it permeates through all kinds of membranes, whether of vegetable or animal nature, with singular ease. A jet of hydrogen gas which strikes perpendicularly upon a sheet of paper, passes through it almost as easily as if there were no obstacle present. The quantity of any gas which permeates through an envelope, of whatsoever nature, is in inverse ratio to the square root of its density (specific gravity). Now, the density of hydrogen is 14½ times less than that of air; hence, about four times more hydrogen passes through the membrane of a balloon into the air, than air passes in to replace it. A constant loss thus goes on, which cannot be remedied, unless some recent experiments on this point by M. Giffard, which appear likely to overcome the difficulty, should meet with success. This is another reason why carburetted hydrogen, or street gas, is preferable for inflating balloons.

All our works on physics agree in telling us that care must be taken not to fill the balloon quite full, for, as atmospheric pressure decreases as we rise, the gas is dilated and would burst the envelope by its expansive force. We have indeed here one of the most necessary precautions that an aëronaut can take. Not only is the balloon never entirely filled, but its lower part, called the appendage, or tail, remains constantly open, so that as the balloon swells on rising, the dilated gas finds easy access from this opening.

A current of cold air, or the shadow of a cloud, sometimes suffices to bring about a condensation or shrinking in place of a dilatation. When this effect is very marked, a small quantity of gas also issues from the same opening. If the balloon were entirely closed, it would be constantly liable to burst, even if it were only partially full of gas, for we cannot tell beforehand how great a dilatation may occur during the ascent, either from the diminution of atmospheric pressure, or by the direct action of the solar rays. The dampness or dryness of the air may also have an effect upon the volume of the gas; so that the above-mentioned precaution is absolutely necessary. Indeed, from not having observed it sufficiently, a well-known aëronaut, Mr. Wells,

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met with his death last year (1869), in the month of July. He was precipitated to the earth near Milan, from a height of some 6,000 feet.

The substance of the balloon is formed of long gores of strong silk or india-rubber cloth, sewn or cemented together, and covered with a linseed-oil varnish to render them as impermeable as possible. The summit of the balloon is enclosed by a wooden hoop, which, in balloons of the capacity of 30,000 cubic feet or thereabouts, is one foot in diameter. It is in this hoop that the valve for letting out the gas is fixed. This valve is composed of two semicircles connected with the diameter of the hoop by hinges. These semicircles push against the upper part of the balloon and open inwards: a rope attached to their centre passes through the balloon and comes out of the opening in the tail; its extremity reaches down to the car. This rope, therefore, represents the vertical diameter of the aërostat. When we stand up in the car, we can see the whole interior of the balloon, and the gores of silk converging to the central hoop and valve.

A net composed of tolerably close meshes is attached to the hoop and envelopes the whole of the upper portion of the balloon. It is to this net that the car is attached; the principal cords of the net are knotted to a horizontal wooden circle, or hoop, nearly two yards wide, from which are suspended six or eight ropes, terminating in strong iron hooks spun firmly into their tissue. Six or eight more ropes spun into the wicker-work of the car, and passing through the bottom of it, where they cross, rise to a little height above the borders of the car, and have their extremities provided with stout metallic hoops corresponding to the hooks of the ropes suspended from the circle. When those hoops are passed over the hooks, the aëronauts can take their places on the seats in the car, with their instruments, maps, provisions, and ballast, and may abandon themselves without fear to the ascensional force of the balloon and the currents of the atmosphere.

When there is no violent wind blowing at the surface of the earth, the most agreeable method is to ascend slowly and progressively. This is particularly necessary (though it has been rarely observed) in scientific expeditions, in order to allow the thermometer and hygrometer time to give proper and reliable indications. This result may be obtained by weighing the balloon exactly, so that at the surface of the ground, just before starting, it has nearly the same weight as its own volume of air. Two men can then hold it down by ropes which are usually left hanging below the car, and when the order to "let go" has

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been given, a few pounds of ballast thrown out of the car suffice to allow the balloon to soar majestically upwards into the regions of the clouds.

It usually rises in an oblique direction, under the combined influence of the vertical ascensional force and the direction of the wind. As soon as it mounts into a stratum of air having the same density as itself, it ceases to ascend (unless more ballast be thrown out), and follows a horizontal course, that of the aërial current. The balloon proceeds with the wind, and is quite motionless as regards the particles of air which envelope it. That is the reason we never or rarely feel a current of air in the car of a balloon, even when travelling through the atmosphere at the speed of an express train.

As a balloon rises in virtue of the difference of its own weight and that of the volume of air which it displaces, we can calculate beforehand both the weight it will carry up and the height to which it will reach.

My second scientific expedition took place on the 9th June, 1867. It was to be made in two stages: observations were to be collected in a zone fixed between 1,640 feet and 2,625 feet of elevation, until sunset; and other observations were to be made the next morning at sunrise, and prosecuted to the greatest height which the aërostat was capable of attaining. The weather was magnificent and highly favourable to our projects.

It might be thought that journeys in a balloon are all very similar, and that the description of one ascent might do for a hundred others. But this is by no means the case. Each excursion has its own special characteristics and its peculiar interest. The state of the atmosphere is so variable, that if we travelled several times along the same aërial route we should still meet with variety, and a long series of careful observations would be necessary to compare the various phenomena observed, in order to render them of some use to science in future years.

In this ascent, as in the first, I was accompanied by two persons. M. Eugène Godard had the care of the balloon, and the other seat was offered to M. de Montigny, who was not to accompany us the next day in the high ascent I had projected.

We started at 5h. 57m. and rose obliquely in a S.S.W. direction, passing over the Palace of the Exposition and the Artesian well at Grenelle. As we crossed above the plain of the Champ de Mars, a peal of bells saluted us: it was rung by M. Bollée, the clever manufacturer of the said bells, who little thought that we should descend next day close to his brother's bell-foundry at Orleans! At six

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o'clock we sailed quietly over Villejuif at the height of 2,543 feet. Here for the first time the tumult in Paris was quite inaudible, and we enjoyed peaceful Nature and a perfectly pure air.

At seven minutes past six we floated over the village of Thiais. The shouts of the inhabitants would have made us aware that we were above a populated district, had we not already noticed the little square roofs of the houses, and the small gardens. It was rather a curious spectacle to see all the pedestrians standing still in every street, with their eyes turned towards the heavens, looking at us. Soon, however, the balloon sailed away across the country, its shadow travelling along over the green fields. On this occasion I made an interesting remark: the said shadow is completely surrounded by a yellowish white aureola, such as is seen painted round the heads of saints. The tint of this aureola is much lighter than the surface of the ground over which it passes. The next day we saw the shadow of the balloon under still more interesting circumstances, as we shall relate presently.

Now we soar rather more to the east, and shall soon cross the Seine at Ablon.

I forgot to note a curious fact when we passed over the spot at which the Marne flows into the Seine. The water of the Marne, which is as yellow now as it was in the time of Julius Cæsar, does not mix with the green water of the Seine, which flows to the left of the current, nor with the blue water of the canal which flows to the right. We therefore see a yellow river flowing, as it were, between two brooks, one of which is green and the other blue. This singular contrast between the waters of the Marne and the Seine subsists even beyond the railway bridge.

If travelling in balloons were commoner than it is at present, what facilities it would confer on topography and surveying in general!

Without taking any tickets or waiting in dusty stations, we quitted the Orleans Railway to take the line to Lyons. Montgéron shows itself for a while at our left hand, and then seems to retire into the distance. The silence which surrounds us is remarkable; it is only interrupted by the hum of winged insects in the country below.

We were just reflecting upon this, and had allowed our machine to descend to within about 656 feet of the earth whilst passing over the Seine, so that we might see things down below somewhat more distinctly, when we were suddenly surprised by the sound of a powerful and sonorous voice: "Come down here! Let yourselves down here! I shall be glad to see you to dinner at the chateau." We thanked our would-be host, but declined his kind offer, passed

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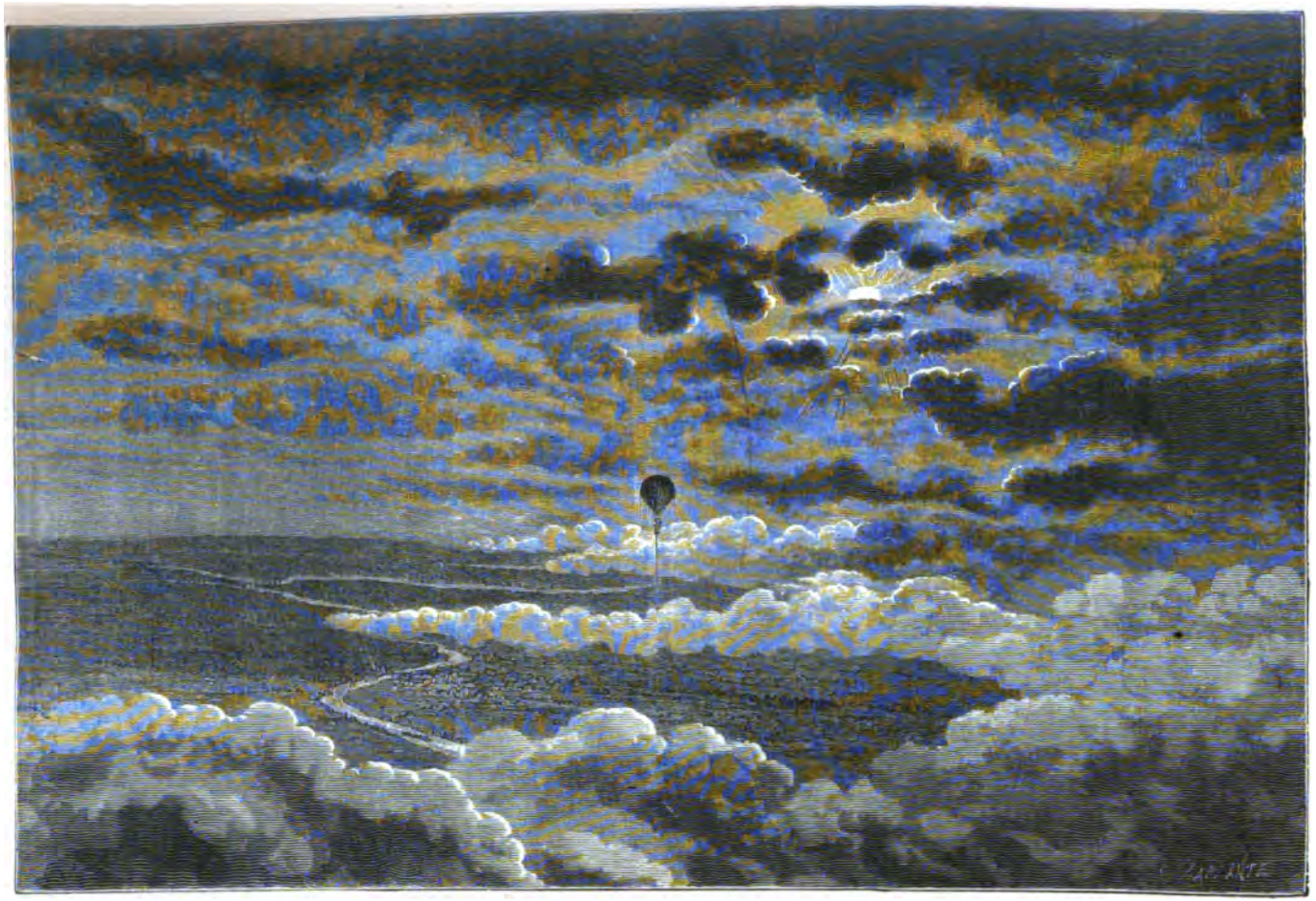

THE SEINE AND THE MARNE AS SEEN FROM THE CAR IN M. FLAMMARION'S SECOND ASCENT.

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UNIV. OF MICH.

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over the Château Frayé, remaining for some minutes at the same slight elevation, and enjoyed the pleasing spectacle presented to us by groups of family parties dispersed over the country, or dining on the green sward in the shade of some noble tree. We then rose to about 1,500 feet by throwing out a little ballast.

I have just said that we allowed the balloon to descend to within a short distance of the ground. My readers will perhaps imagine that this was done by a pull at the valve-rope and allowing some gas to escape. By no means! gas is far too precious to the aëronaut to be wilfully wasted, and we should want all we had the next day. The fact is, a balloon descends of its own accord as soon as it has reached the point to which its ascensional force at first carries it. Although it is composed of two envelopes of silk stuff, it is not completely impermeable, and, besides this, its lower part or neck remains constantly open above our heads. When the solar warmth causes the gas to dilate, some of it escapes from below. Again, when the atmosphere cools in the evening, the aërostat shrinks somewhat, and, occupying a smaller volume, becomes a little heavier than before. It therefore descends naturally towards the earth. A clever aëronaut rarely touches the valve-rope—except indeed to open this valve completely when he descends for good; he must be able to keep the balloon at one given height by means of a judicious management of his ballast; a single handful of ballast quietly let out causes a considerable rise.

Rising again into the air—coming over the forest of Sénart, on the Mainville side—we once more get a glimpse of Paris in the north-west; and the city appears covered by an immense cloud of dust, which is whitened by the rays of the sun. This vast accumulation of dust is doubtless to be attributed to the stir created by the feet of the many persons who have come to visit the National Exposition, without counting that which is raised by horses and carriages. Nevertheless, from this position we distinguish certain towers like so many masts, those of Notre Dame, the Sainte-Chapelle, the Pantheon, the Invalides, and the Arc de Triomphe. What a difference between this dusty atmosphere and the pure air we are breathing over the green fields and the forest trees!

When over the heather, we hear the mournful call of the quails. The aërial skiff pursues its horizontal course between the Orleans and the Lyons lines of railway. We must be approaching a village, for loud shouts reach our ears. It is Tigery, and we are passing out of the Seine-et-Oise into the department of Seine-et-Marne. Corbeil recedes from us on the right.

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Butterflies hover round the car of the balloon. Until to-day I imagined that those little things passed their short existence among the flowers of the fields, and that they never rose to any great height in the air. But in fact they rise higher than any of the birds of our forests, and soar to many thousands of yards above the ground, as we were able to convince ourselves a little later. Another thing strikes us: they do not appear to be frightened by the balloon as birds are. How is this? It may be that great weakness has nothing to fear from great strength; and perhaps the eyes of these insects do not see things as the eyes of birds see them.[1] . . . Thus, at every moment, a thousand unexpected problems present themselves on an aërial voyage of discovery.

At twenty minutes past seven a slight fog spread itself over the country; the same observation was made, but an hour earlier, on our last voyage.

A train passes beneath us, running towards Lieusaint, and the harsh whistle of the locomotive strikes our ears. What a dust and what an infernal noise they make, and, after all, how slowly they go in comparison with the rapidity of our smooth and silent course through the pure air!

Some small parachutes which we throw out from time to time fall towards the ground with a spiral motion.

The Seine stretches over the country like a silver serpent more or less coiled up. From our balloon we could make a splendid survey of the district beneath us. The view, as we cross the river and follow the route from Pringy to Chailly, is one marvellous panorama, whilst the odour of the green woods rises up to us and forms the sweetest of perfumes.

As the sun sank below the western mist, the heavens around us were lit up by a warmer tint, and the entire plane was tinted by its oblique red rays. We heard the watchdogs of the peasants bark, and sometimes we saw hundreds of persons running together under the balloon, thinking it was about to descend into their fields. By consulting the map of the country we found that we were travelling towards Nemours; but we could not have reached it at that height, for we had not enough ballast left to enable us to pass over the forest

[1] May the fact not be explained by assuming that butterflies are carried up into these high regions by currents of air which they cannot resist, but which are not strong enough to take effect on birds? It is nevertheless astonishing what a powerful current of air a common house-fly on a window-pane can resist.—T. L. P., *Translator.* [I never saw a butterfly, or any winged insect, at any elevation, and the few insects I saw were doubtless taken up by the balloon.—Ed.]

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of Fontainebleau. As my evening observations were all made, we decided on descending near to a charming little village—exceedingly small as seen from the sky—which lay snugly, like a young deer, on the borders of the forest. This village was about a mile and a quarter on before us. The scattered population of the district noticing that the balloon was about to descend, imagined that we were making for Chailly, and the inhabitants of this place had already run out to meet us; but we passed quickly over them. Soon, however, all the pedestrians dispersed over the country ran together in a considerable crowd underneath us. The sky was deliciously pure, and the air at the surface of the earth absolutely calm. Slowly and gradually we float towards the ground. Cries of "Come down, come down! we will take you back to Barbison . . . dinner is waiting for you," assail us on all sides. We throw a rope, and some three hundred people make a rush to seize it; a few broken noses do not appear to check the enthusiasm at all. In an instant the rope is seized by fifty stout hands, and M. Godard then shouts to them to move along the road and not to injure the crops. The recommendation is carried out unanimously; the road is gained, and we are towed at 500 feet from the ground to the entrance of the village of Barbison, long celebrated as the resort of artists and huntsmen. On this occasion, indeed, the *cors de chasse* sounded by the men who walked on before echoed wildly through the forest shades.

We descend with truly royal gravity—how different from our first descent! The ladies who were enjoying village life at Barbison were very anxious to test their feelings in a balloon. We all know how anxious the daughters of Eve are to experience any new sensation. Godard took some of them up in the captive balloon to a height of some 500 feet, whilst I placed my instruments in their cases and made acquaintance with some of the distinguished artists who come here to study Nature.

The car of the balloon was safely placed at the side of the road and loaded with heavy stones. Two men mounted guard near the balloon all night, and I assured them that if they smoked near it, they would probably inflame its vast volume of gas, and that it would destroy all the country around; also, that if they touched the envelope and made the smallest hole in it, the gas would issue from it in torrents, suffocating and poisoning the whole neighbourhood, and probably also the adjacent villages in less than ten minutes! I need scarcely add that the balloon was well guarded. Numbers came from every quarter of the place, and during the whole of the evening, to inspect the aërial pilgrim as it stood majestically gently oscillating

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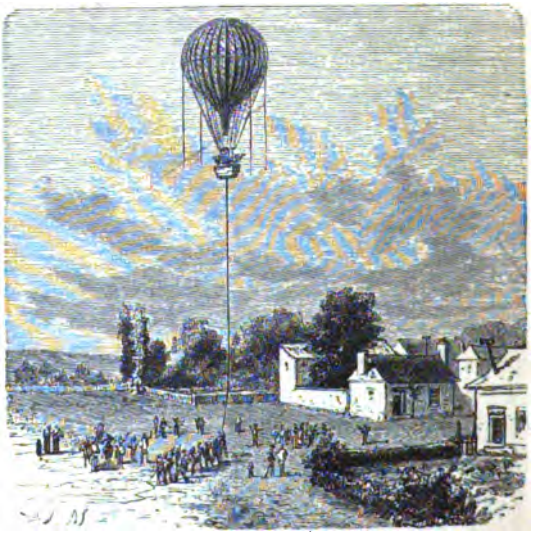
at the extremity of the Grande Rue. Diaz, the well-known figure-painter, took it into his head to sketch the profile of a boy who stood before us with his arm stretched out, and he placed the balloon, which formed the background to his sketch, on a level with the boy's hand, as if he were holding up a magnificent top.

To those who look upon aëronautic expeditions as frivolous, and not worth the attention of scientific men, I cannot do better than quote the following words pronounced by Arago on the occasion of Gay-Lussac's ascents. "Beautiful discoveries," he said, "will reward those who make scientific excursions in balloons. It is much to be deplored that those ascents which are made almost every week in more and more dangerous circumstances, and which must accidentally terminate in some fearful catastrophe, should have the effect of causing scientific men to give up their proposed ascents. I understand their scruples, but do not share them. The spots on the sun, the mountains of the moon, Saturn's ring, and Jupiter's belts, have not ceased to occupy the attention of astronomers, though they are nightly to be seen for one penny on the Pont Neuf or on the Place Vendôme and other open places. The public of the present day is too enlightened to confound together for one moment those who risk their lives to gain a livelihood, and astronomers or meteorologists who run into danger in order to wrest from Nature some of her secrets!"



CAPTIVE ASCENT AT BARBISON.

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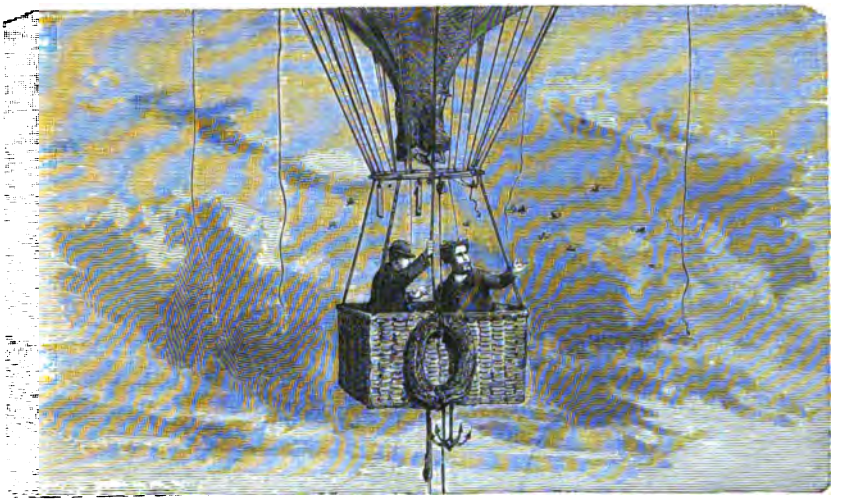

BUTTERFLIES HOVERING ROUND THE CAR OF THE BALLOON.

CHAPTER IV.

MORNING ASCENT—THE BLUE SKY—THE RESPIRABLE ATMOSPHERE.

A THIRD part of our existence is passed in sleep: eight hours a day, on the average, including the time occupied in preparing for sleep, or in rising. If we observe, moreover, that the first fifteen years of our life, or thereabouts, are gone before our intellectual faculties are sufficiently developed, we find that a man who thinks he has lived sixty years because he happens to have arrived at that age, has in reality only enjoyed life for thirty years. Again, if we subtract from these thirty years the time necessarily lost in eating and drinking, and time wasted or spent unprofitably, we find that the longest existence on this earth, however well occupied, is quite insignificant when compared with the time which is required for the development of scientific research.

Whilst morning slumber retains us on our soft couches, Nature accomplishes marvels upon the earth.

Our balloon remained all night, inflated and ready to start, on the confines of the forest of Fontainebleau. Next morning, at break of day, we sallied out to take possession of it again, and to return into the regions of the air. I busied myself with the necessary preparations for the observations that were about to be made, and took my seat in the car, Godard having placed himself

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opposite and taken the management of the balloon; whilst our other companion took leave of us.

It is the 10th June, 1867. Time: sunrise. The air remarkably pure, and the country around scented with the damp perfume of the fields and the woods.

We quit the ground at five minutes to four o'clock, and rise very slowly on account of the dew deposited during the night upon the surface of the balloon and adding to its weight. Some peasantry, going early to work, stay to see us start, and stand in a circle round the balloon, gazing at us with astonishment as we ascend.

We see the sun rise majestically above the misty horizon, but the silence of the morning surprises me. I was accustomed to believe that, at such a moment, birds sing and insects buzz, and all living beings duly recognize the advent of day. This morning, however, though the sky is wonderfully clear, the rays of the morning sun cause no such effect, and seem to be received by Nature with a kind of indifference.

The balloon, on leaving, passes over the little village whilst we are scarcely 330 feet above the soil; the dogs of the village either see us or scent us, for they bark furiously, whilst turkeys, ducks, and cocks crow often; our appearance in the sky frightens them; numbers of large black crows fly off with plaintive cawing as we approach.

The wide fields appear covered with water, but it is merely the white fog which lies upon them; from a distance they resemble vast lakes. When we pass directly over these layers of fog, they appear formed of so much swan's down.

The direction of the current which carries us away to-day is precisely at right angles to that by which we arrived in this district yesterday. We are travelling towards the south-west. This is the lower current. A little higher it becomes south-south-west, and, higher still, it will carry us directly south. In descending we shall pass again into the S.S.W. and S.W. currents, so that our course, traced horizontally over the ground, will represent the figure of a very elongated S.

At the surface of the earth an absolute calm has reigned since sunset; but the higher we rise in the air the more rapid the current becomes. The contrary generally holds good during the day, especially just before and after noon.

Our morning ascent is enlivened by the song of the lark. We pass over a hill of reddish-coloured rocks, which, seen from a

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distance, has the appearance of being covered with autumnal leaves. A very light, wide-spread fog exists beneath us. Our height is now 2,411 feet. The sky is quite clear, but a zone of grey vapour lines the horizon, and rises to a height of 394 feet; we are just rising out of it.

The humidity of the air was very great when we left; it was indicated by 93 in a very accurate Saussure's hygrometer. It nevertheless increases as we rise, until a height of 492 feet is reached, at which point the hygrometer stands at 98. As we rise above this, the humidity diminishes. At 919 feet it is indicated again by 93, as upon the ground; at 984 feet it is 92; at 2,461 feet we note 86; at 3,609 feet, the hygrometer stands at 65; and at 3,832 feet at 64. So that the atmosphere evidently becomes gradually drier the higher we rise.

Some little white butterflies fluttered round the balloon when we were about 3,281 feet above the earth. We rose to a height of 4,101 feet; our thermometer was then 7°·2 Fahrenheit lower than at the surface of the soil when we started; the hygrometer stood at 62, and our timepiece marked 4h. 55m.

A singular phenomenon is observed with regard to the *shadow* of the balloon. We saw it yesterday evening travelling over the fields, and it was *black*, circular, and surrounded by a slight penumbra and an extensive aureola. It is now *white*. It appears like a vast luminous patch covering several acres of ground; it is much larger than the little town of Milly. This appears to me so surprising that I pass at least half an hour in observing it, in order to convince myself that it is always opposite the sun, and that it travels along with us. The surface on which it falls, whether forest or field, appears more luminous than the rest of the country. Can it be possible that the balloon produces the effect of an immense glass lens?

This phenomenon was observed till a quarter-past seven, when it ceased to be visible. At half-past seven the *shadow* was *black*, and had an aureola or halo round it. A person placed in this *shadow* might have attributed it to the effects of a curious kind, and it may be imagined, from the preceding observation, that shortly before the eclipse would have been a luminous one; but attentive inspection of the phenomenon shows it to be what is called an *anthelion*.[1]

[1] Anthelia are not exactly rare phenomena upon the surface of the earth, but they are not often seen to great perfection. According to Fraunhofer and Kamtz (*Meteorol*, chap. xix) they are caused by diffraction. Mr. J. S. Tute, when in a boat

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At a quarter-past five we pass over Gollainville, leaving Malesherbes on the left. We are entering the Loiret, and our flight appears to be directed towards Pithiviers. We are now 4,921 feet high, and, nevertheless, the most minute details of the vast tract of country beneath us are easily distinguished. The Orleans forest is prominent in the south-west, and beyond it the town of Orleans itself can be perceived; but it requires a good glass to recognize the towers and the two white bridges.

The limit of our horizon extends to a considerable distance beyond this. We now endeavour to ascertain how long sound would take to reach us from the earth's surface, but our efforts are in vain; our most powerful notes cannot arrive at the ground from such a height, and no sound returns to us.

We hear, nevertheless, the whistle of a distant locomotive; and, more than this, the barking of dogs in the village of Coudray, and the guttural cackling of fowls, are distinguished with tolerable ease.

The roads and lanes spread over the ground are now reduced to mere thin strings, and the whole country is dotted over with liliputian villages which we might count by hundreds. At half-past five we were over Boissy-le-Brouard, at a height of some 5,742 feet. Butterflies again hover round us. What can they be doing at such a height? Did the balloon carry them up with it? However this may be, they fly about as if they were in their natural atmosphere.

The exact height of the balloon, determined by means of two barometers,—namely, a mercurial by Fortin and an aneroid,—is 5,906 feet.

The green wooded valley which extends from the west of Pithiviers to Malesherbes appeared to us something like a river, and Pithiviers itself like a spotted dice. This winding valley is nevertheless from 1,969 to 2,297 feet wide.

at sea, whilst the sun shone, noticed a peculiar brightness round his shadow on the water. The same effect has been seen, less perfectly, in strong moonlight, when the *shadow* of an object is thrown upon grass covered with hoar-frost. Similar effects are sometimes observed when shadows fall on the slopes of mountains, or over wheat fields, and have been witnessed, likewise, by Scoresby, in the Arctic regions. When the sun is near the horizon, and the shadow of an object falls on a surface covered with dew, an aureola is observed around this shadow. In some cases coloured bands are seen; it is when the rays of light pass through two systems of vesicules. The curious phenomena of the diffraction of light were discovered in 1663, by Grimaldi, of Bologna. They are explained in works on natural philosophy, and the phenomenon is alluded to again by the author in a subsequent chapter.—T. L. P.

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From La Beauce we pass on to Gâtinais. The ascensional force of the balloon can still be increased. The barking of dogs becomes much fainter; it is heard, as in a dream, and for the last time. The solar heat is felt with more intensity on our faces, for the cold increases at our feet in the car, and not the slightest breath of air comes to moderate the effects of the sun's bright rays. We pass on to the eastern limit of the Orleans forest, at Vrigny-aux-Bois, and at an elevation of 7,054 feet. We see the whole extent of the forest, and even as far as the Luxembourg Garden in Paris, the avenues of which, crossing each other at various angles, are quite distinct. It is now six o'clock, and our aërial skiff still sails upwards; at twenty minutes past six we are 8,858 feet high, and at half-past six we are no less than 9,843 feet above the earth.

We may be said to have soared higher than the summit of Mount Olympus, that ancient and solemn mythological mountain of Thessalia, which, according to the most recent barometrical measurements, made in the manner we have described above, is only 9,534 feet high, and does not touch the sky as the contemporaries of Homer fondly imagined. The gas bottle to which we are suspended in the air rises at thirty-eight minutes past six to 10,827 feet, measured perpendicularly, above the river Loire.

Here the most magical panorama which fantastic dreams could evoke presents itself to our contemplation. The central district of France spreads itself out beneath us as an unlimited plane, as rich in colour as varied in tint, and which I can only compare once again to a magnificently-painted geographical map. The space around us is of the most perfect transparency. In the midst of these blue heavens I rise from my seat, and leaning my arms upon the edge of the car, I glance downwards into the immense abyss. . . .

Down below, at 10,000 and odd feet beneath me, exist the universal radiations of life and activity; plants, animals, and men are breathing in the lower strata of this vast aërial ocean, whilst here above animation is already on the decline. Here we may contemplate Nature, but we repose no longer on her bosom. Absolute *silence* reigns supreme in all its sad majesty. Our voices have no echo. We are surrounded by a vast desert. . . . .

The silence which reigns in these high regions of the air is so oppressive that we cannot help asking ourselves if we are still alive. But death does not reign here; we are impressed only by absence of life. We appear to appertain no longer to the world down below.

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The vast scene towards which we are about to descend, how admirable it is!

What tranquillity, and what treasures! Who could imagine that in so delightful a residence man can live ignorant and corrupt, deprived of these splendours, creating war and crime upon this glorious bosom of beauty and of love!

The absolute silence of which we have just spoken is truly imposing; it is the prelude of that which reigns in the interplanetary space in the midst of which worlds revolve. The sky here has a tint which we never saw before. Above us it appears of a dark greyish blue; its transparent and unfathomable colour gradually fades; at 45° it is azure, at 25° pale azure, and on a level with our horizon nearly white. Here the vault of heaven reposes on a circle of well-defined clouds.

I shall teach nothing to my readers by informing them that the blue celestial vault has no real existence. The air reflects the blue rays of the solar spectrum from every side. The white light of the sun contains every colour, and the air allows all tints to pass through it except the blue, which it appears to choose specially, and to reflect in every direction. This causes us to suppose that the atmosphere is blue. But the air has no such colour, and the tint in question is merely owing to the reflection of light. If the air were blue in reality, distant mountains covered with snow would, as Saussure once remarked, certainly appear blue; but this is not found to be the case. The air is colourless, but it is not absolutely transparent, since it retains and reflects the blue rays of solar light.

Planetary space is absolutely black. The higher we rise towards this external space, the thinner is the layer of atmosphere which separates us from it, and the darker the sky appears. At a height of 9,843 feet we have passed through more than one-third of the atmosphere, as far as *weight* is concerned. It is therefore not surprising that the air above us should appear so dark, and that this shade should gradually decrease towards our horizon. The decrease of moisture adds its effect also in diminishing the intensity of the blue tint above.

At this height we see the blue colour of the air beneath us as a faint veil. As we rose the dryness of the air has increased. At the highest point of our course the hygrometer marked only 25. The thermometer suspended in the sun's rays marked 73°·4 Fahr., whilst that in the car was at 46°·4. A little later, during the descent, these two instruments indicated 77° and 50° respectively. For a long period

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ABSOLUTE SILENCE REIGNS SUPREME IN ALL ITS SAD MAJESTY

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of time we experienced a difference of 27° Fahr. between the temperature at our heads and that at our feet.

One of the results of this excursion was to convince me that the blue colour of the sky is principally attributable to the presence of watery vapour in the air; and at an elevation of 9,843 feet this moisture has diminished some three-quarters of its mean amount as registered on the surface of the ground.

I did not expect to feel unwell on this excursion, and I can scarcely say how it was that at a quarter to seven I felt a peculiar internal chill, accompanied by a sensation of drowsiness. I breathed with some difficulty, I had a singing in the ears, and for the space of half a minute was troubled with palpitation of the heart. A dry feeling in the throat, and the buzzing and singing sounds in the ears, may perhaps be attributed to the rapidly increasing dryness of the atmosphere. I drank a glass of water, which did me much good. In uncorking the bottle which contained it, the cork flew out with a report as if it had been champagne. This phenomenon is at once accounted for by recollecting that we had at least one-third less air above us than at the surface of the earth, and that the atmospheric pressure was here reduced to two-thirds of what it was when we corked the bottle before starting.

I was careful not to say anything to M. Godard as to my feelings, being anxious to rise as high as we possibly could. Unfortunately, my aëronaut himself experienced a sudden feeling of sickness about this time. At this moment we noticed that sounds made in the car of the balloon were echoed back from the vast envelope of the aërostat, which, as I have already said, is open at its lower extremity, and came upon us as they would in a large empty concert-room. I then shouted into the air as loud as possible, and though the sound was not returned by the earth, it came back to us with a sharp ironical accent from the envelope of the balloon itself.

At what height might we have been at this moment? To this question I can furnish no precise reply, for having moved a plank in the car of the balloon, in order to write more at my ease, I unfortunately broke the tube of the mercurial barometer, the liquid metal of which glided away into space beneath us. As for the aneroid, it had already gone to the extremity of its course, and could supply no further information.

The balloon was isolated, as it were, in a vacuum; beneath us stretches an immense abyss, above the infinite expanse of sky. The sun appears less bright, probably on account of the absence of any reflecting surfaces around us. Our aërostat revolves, from time to

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time, around its axis, and the sun is sometimes seen on one side of us, sometimes on the other, sometimes before us, and then again behind us, though our course itself is invariable. When we stand up in the car to endeavour to recognize any given object on the earth's surface, we find occasionally that we are turning as we sail along.

As our instruments no longer tell us how high we are, Godard thinks it time to open the valve to descend a little. He confessed to me afterwards that in the whole of his 905 ascents he never before rose to such a height as this. Alas! the man who was modest enough to call himself my coachman, and whom I liked better to surname my aërial automaton, could no longer obey my orders; his perfidious hand already grasped the valve-rope! . . . . .

At this moment we distinctly heard the shrill whistle of a locomotive. We had just passed over the river Loire, at Châteauneuf, and we sought in vain for the railway whence the whistle proceeded. The origin of the sound was in reality only forty-nine feet above us: the gas, as it issued from the balloon, whistled like steam.

We were obliged to open the valve several times, and to allow more than 300 cubic feet of gas to escape before the aneroid barometer, which had ceased to record any pressure, showed by a slight motion of the index that we had really begun to descend in earnest. When the balloon is at its maximum of dilatation, as ours was at that moment, to let out gas is equivalent to throwing out a similar weight of ballast, so that, instead of descending immediately, we at first rose a little higher.

After having lost the considerable volume of gas just mentioned, we sank down from the unknown height to which we had soared, and when we arrived at 10,827 feet elevation the index of the aneroid (which for the last quarter of an hour had been at the extreme point of its course) began to move back again; its movement was rapid enough to be followed by the naked eye. We sank very swiftly indeed, until we were only 5,249 feet above the earth, and the balloon was again in a state of equilibrium.

The Loire, which we passed over five minutes ago, looks like a thin ribbon; we distinguish the bottom, with its streaks of sand which mark its course and its overflow along the banks. Its aspect is that of brown marble.

The geometrical figure taken by the earth's surface, as viewed from such a great elevation, is somewhat paradoxical. The earth being a spherical globe, it might be thought that on rising high above the surface we should see something of this spherical shape. But the

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contrary is experienced in reality. As we mount higher the surface of the earth, instead of this, actually flattens out, and seems to becomes *hollow* underneath us, so that we feel that we are sailing, as it were, between two concave glasses, the sky and the earth, which seem to be soldered together at our horizon, and the concavity of which is very considerable both above and below us.

This unexpected effect can be explained by the laws of perspective, in the same manner that we account for the apparent sinking of clouds from the zenith to the horizon.

We descended almost in a straight line over Tigy, and now we are sailing over La Sologne, at a height of about 5,249 feet. We have remained at this elevation since six minutes to seven o'clock. Instead of continuing our course to the south, we have taken a south-south-west direction. I cannot help admiring the scene below; neither the ocean seen from the highest cliffs, nor the grandest views in Switzerland, are comparable to this magnificent plain beneath us. (Certain observers at Châteauneuf saw our aërostat about the size of a man's hand. The most powerful glasses did not enable them to distinguish the network on the ropes.)

Death-like silence still prevails. We are slowly descending. The buzzing in my ears recommences, and is more intense and disagreeable than before. It is really quite troublesome, but gradually subsides in about ten minutes. (Half an hour after landing a fit of incessant gaping came on; the air seemed to enter gradually, and by intermittent puffs, into the inner portion of the ears.)

Some small parachutes which we throw out indicate that the currents are variable underneath us. The immense plain of La Sologne spreads itself out below, dotted with numerous ponds of water.

As we have decided to come down, we pull the valve-rope again, after having sailed for some time at a height of about 5,249 feet. This extra loss of gas brings us down to 3,281 feet, and then to 1,969 feet, at which height the balloon is again in equilibrium, and we continue to sail along. It is much more prudent to descend gradually in this manner than to allow a large escape of gas to take place all at once, and to sink with dangerous rapidity; moreover, it allows us to choose our landing-place.

The thermometers gradually rise, and the hygrometers again indicate increased dampness in the air; the weather has remained fine, and the song of the birds is now heard anew. We are only 1,640 feet from the ground. We feel as though we had landed; and whatever may be the degree of excitement or scientific interest that attaches

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to these balloon excursions, I must confess that a certain amount of tranquil pleasure assumes its rights as we approach the soil which we have trodden from our childhood.

We are saluted by the reports of two guns. It is the Mayor of Sennely, who has perceived our intended descent, and has already harnessed his horses to come out and meet us. We pass directly over the great oak-tree of Harronnières, which measures twenty-one feet in circumference; the larks are singing gaily above the fields; we leave to our left the imperial domain of La Grillaire, and prepare for landing.

At this moment some children who are tending the flocks raise most distressing cries, and rush away with fright. They beat on their poor animals before them, and endeavour to get as rapidly as possible out of our way, for the balloon is descending obliquely, and its ribbon flags, waving fantastically at each side of it, appear like long arms or tentacles! It is some formidable being coming from the clouds—it's the Devil himself!

Fortunately, the great majority of the villagers were not of this superstitious character, and knew that the monster in question was only a balloon. We landed safely in a field at Vouzon, in the canton of Lamothe-Beuvron (Loir-et-Cher), at a quarter to seven o'clock. The distance travelled in our journey of yesterday and that of this morning amounts in all to 120 miles, which has been accomplished in six hours and twenty minutes, during the whole of which time we never felt ourselves in motion at all.

The mean velocity of the balloon may be stated, therefore, to have been twenty-three feet per second. In our first journey the velocity was somewhat greater, having been about twenty-six feet, and as much as thirty-three feet per second as we approached the storm.

Soon after our descent a south-west breeze sprung up, and increased with intensity till twelve o'clock. Our balloon would have enabled us to remain much longer in the air, and, had we continued to move in the same zone and with the same velocity, we should have arrived at Bordeaux before sunset; but the object of this excursion was to make observations at a great altitude.

I have been requested, in some letters addressed to me regarding my remarks in the *Siècle*, to define accurately the law which appears to regulate the distribution of moisture in the air as we ascend. The figures above given only relate to its gradual decrease on the day in question, and many more observations are required in order to reply to such queries. Nevertheless, I may state here that a careful investi-

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gation of the variation of moisture with the height, and of the variation of temperature corresponding to it, which were the principal objects of this ascent on the 10th of June, have led, with the results of my other excursions alluded to further on, to the conclusion that the moisture of the air increases as we leave the ground until a certain zone is reached, when it appears to be at its maximum. After this, as we mount higher, it diminishes constantly to the highest regions we can reach. As the moisture decreases, the diathermacy of the air, or its transparency for heat, increases, so that the solar rays travel through the atmosphere in the higher regions without being absorbed. It results from this that the air itself is very cold, whilst the direct rays of the sun are very keenly felt. Hence it follows that the invisible watery vapour contained in the air plays a more important part as regards temperature than the constituents, nitrogen and oxygen, of the air itself. This moisture retains the warmth, and to it we must attribute the temperature of the air as given by the thermometer at different seasons of the year.

I have been asked to what height is it necessary to ascend above Paris before a zone of pure fresh air is met with, and when every one suffers from heat in the town below? I may reply to this that it is requisite to rise at least to an altitude of 1,600 feet before we can consider ourselves quite free from Parisian dust, and that the air is never perfectly pure and agreeable until we have soared beyond the fortifications.

It was a medical gentleman of Issoudun who asked me the latter question, and I may therefore take this opportunity of stating that the day before I started on this aërial excursion I was suffering from a severe attack of influenza, and had passed a feverish night without sleep. My friends tried hard to prevent my departure, and I had no little difficulty in escaping. But, it must be remembered, there are no draughts in a balloon. In the air itself you are beyond the influence of the air! and when you rise only to a moderate height you find yourself in an exceedingly mild climate, where you are not troubled with the slightest breath of air. The fact is, that my influenza passed away whilst I was in the balloon, and I recommend this observation to the faculty; for the day will perhaps come when they will send their patients up to take air-baths instead of prescribing Trouville or Biarritz.

We found that the silk globe of our aërostat, which was covered with dew when we started, had been so thoroughly dried by the direct rays of the sun, whilst we soared in the higher regions, that it appeared as if it had been exposed to a hot fire; and had not the

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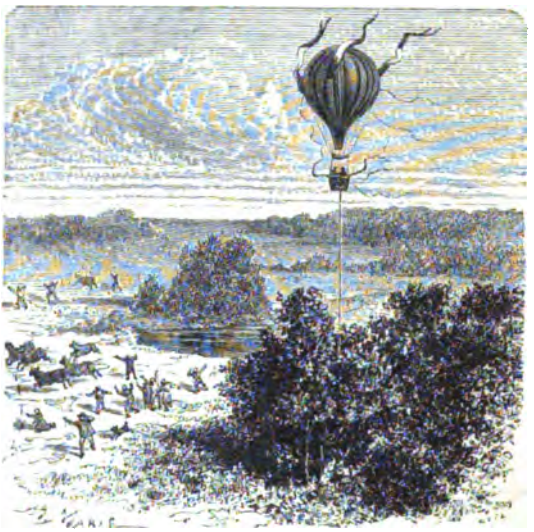
balloon been open at the neck, as we have before stated, it would inevitably have been burst at so great an elevation. After having folded it carefully and placed it in a waggon, we found our way, seated on this marvellous tissue which had carried us up to a height of 10,000 feet, to the railway station of Lamothe-Beuvron.



"IT'S THE DEVIL HIMSELF!"

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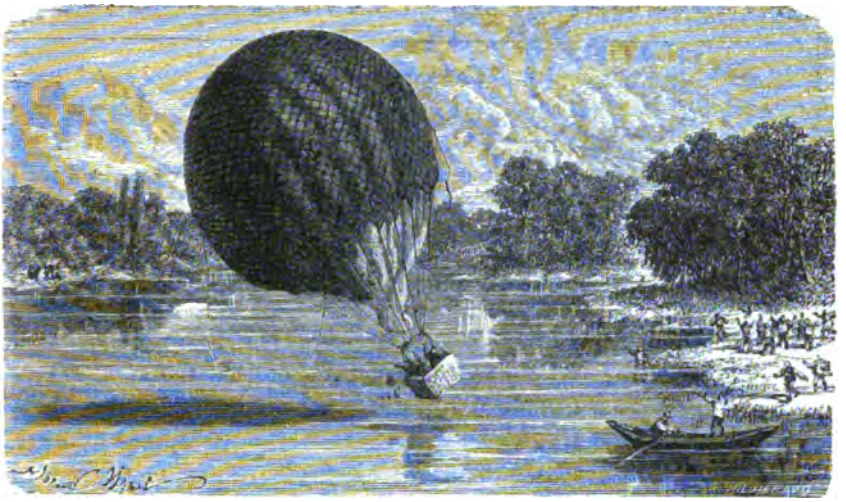

"THEY ARE DROWNED! . . ."

CHAPTER V.

A VOYAGE IN TWO STAGES—EVENING: ST. CLOUD, VERSAILLES, DREUX. NIGHT: VERNEUIL, LAIGLE, DESCENT INTO THE RIVER ORNE.

I.

THE ascent on Tuesday, 18th June, was in a westerly direction from the very moment of our departure. In the evening ascent I was accompanied by Baron de Rochetaillée and M. Eugène Godard; in the night ascent, by M. Godard only.

Though the Arc de l'Etoile may be considered the grandest and most imposing entrance into Paris, the western end of the capital is decidedly the most magnificent for leaving it in a balloon. We get clear of the town at once, and plunge into a region of silence in the first minute of our excursion. We have scarcely said adieu to our friends when we find ourselves over the green coquettish garden of the Bois de Boulogne, with its brilliant ponds of water, and here and there a little white sail like the wing of a swan, whilst the narrow golden-coloured paths wind about the great park in elegant and graceful curves. The woods of the various plantations, varying in shade, present the aspect of so many delicately cut emeralds, darker or more transparent, according to the inclination of the numerous facets. Man alone has not produced this work of art; Nature has also taken her part in it, and animated the whole scene.

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The green avenues have passed away, and now the celebrated park of the Château de la Muette appears beneath us. Here it was that, on the 21st October, 1783, at half-past one in the afternoon, *the first aërial voyage* was accomplished. Here it was that man first dared to abandon himself to the unknown regions of atmospheric space!

Some of our readers may perhaps remember that it was not without some difficulty that Louis XVI. would allow this first journey in the air to be made. He feared lest the travellers should be deceived and lost in the unknown regions of the meteors, or that the *Montgolfiere* which carried them would take fire, and not only destroy their lives, but cause a conflagration along its route.

The King would only permit the experiment to be made by two criminals condemned to death. But the proud and courageous Pilâtre de Rozier, *the first aëronaut*, was indignant at the idea "that vile criminals should have the glory of being the first to rise into the air." He made every effort to ward off such a calamity, and, thanks to the Duchesse de Polignac, governess of the royal children, he at last obtained permission to make the first balloon ascent with his friend the Marquis d'Arlandes.

It was from the courtyard below us that the aërial fire machine rose and sailed across Paris, and among the witnesses of this extraordinary ascent was Benjamin Franklin. This appears to have happened a long time ago, but in reality it is scarcely eighty years since, and it is just possible that some of our readers may actually recollect the remarkable occurrence.

Alas! only two years later, this same intrepid Pilâtre de Rozier, accompanied by M. Romaine, lost his life in endeavouring to cross the Channel by means of a fire-balloon, above which was attached a gas-balloon. They were scarcely twenty minutes in the air before the two balloons caught fire, and the two unfortunate men were precipitated to the earth at some three hundred yards from the seaside. M. Romaine still showed some signs of life, but Pilatre de Rozier was completely dead, and all his bones were broken. He was twenty-eight years of age, and engaged to be married to a young lady then at school at Boulogne, who, according to the accounts published shortly after this deplorable accident, could not survive the effect of it, and died in convulsions eight days afterwards.

My memory had scarcely time to call forth these historical details whilst passing over the spot where the first balloon ascent was made by man, than our aërostat had glided over the Château of St. Cloud. We pass over the Seine, and over the private park where the future

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Charles X. and father of Louis Philippe made an ascent in 1784—it was at a moment when the throne was very unsteady, and it was hoped, perhaps, that a more solid state of things might be found up above.

A-propos of this ascent made by the Duc de Chartres (Philippe-Egalité), the good-natured Madame de Vergennes said that it was neither for love of science nor for the sake of the danger, but simply to place the Duke a little above his difficulties; in fact, that it was the only way left of keeping his head above water!

We left at a quarter-past five, and in ten minutes our balloon floated at a height of 1,970 feet above the Bois de Boulogne. The hygrometer then marked 60 and 61, in lieu of 57, at which it had stood a little time before; and the thermometer had sunk some 7° Fahr. It is probably to the increased humidity of this region that we must attribute the following fact :—

The balloon ceased to rise, and began, on the contrary, to descend rapidly. In the space of two minutes we threw out no less than forty pounds weight of ballast, in spite of which we sank from 1,970 feet to 755 feet in about three minutes. It was at this slight elevation that we crossed the Seine; the loss of a few more pounds of ballast allowed us to rise slowly to the height of 3,543 feet, at which we passed over Versailles.

Not only is the landscape here, as I said above, one of the most charming, but the country passed over is celebrated in the annals of aërostation. It was from the great courtyard at Versailles that the first attempt at aërial navigation was made, in presence of Louis XVI. and Marie Antoinette, on the 19th September, 1783. To the basket car of a Montgolfière, or fire-balloon, a sheep, a cock, and a duck were attached on this occasion; and I find in the *Mémoires Secrets* of Bachaumont, a curious letter, dated from Versailles on the 19th September, in which he says: "When the car and the balloon were found after the voyage, at Vaucresson, the sheep was grazing quietly, the duck appeared in perfect health, but the cock had broken its head." I also find in this letter a very curious fact which is not generally known. "They (the two brothers Montgolfier) had caused all the old shoes that could be collected to be brought here, and threw them into the damp straw that was burning, together with pieces of decomposed meat; for these are the substances which supply their gas. The King and the Queen came up to examine the machine, but the noxious smell thus produced obliged them to retire at once."

By this time Paris had disappeared in the evening mist; the last

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glimpse we got of it might be represented by a plain covered with white stones, lit up by the last rays of the setting sun. We have St. Cyr on the right. It is ten minutes past six, and the balloon has turned half round, the sun now being on my right hand instead of on my left, as it was a few minutes before. We pass over the Lake of St. Quentin, and before us we see sparkling the pond of the Château de Pontchartrain towards the north-west.

The crowing of a cock is distinctly heard; it is a sign of the existence of civilization in the neighbourhood; and, in fact, we are just over the village of Notre Dame de la Roche. At present we are gliding over the castle, I suspect, at the slight elevation of 160 to 330 feet, according to the undulations of the soil. Above the beautiful valleys we sail along at a height of about 330 feet, and on passing over the hills we almost touch the trees. We might easily rise to six times this height by throwing out a little ballast, but the aspect of the country is so beautiful this evening that we do not care to do so. Moreover, we have some observations to make in these lower strata of the air with regard to damp and dew.

The hygrometer rose gradually to 70 as we passed into these low strata, and as the evening advanced. Our velocity has been very variable: 1,230 feet per minute at starting; 1,263 feet per minute above Versailles; 1,017 feet per minute after we had sunk down to a height of 500, to 1,362 feet while passing near Essarts and Villemeux.

As we come over Essarts the children are frightened by our appearance, and utter shrieks of terror, the village ducks fly off to a distance, all the inhabitants run out of their houses and follow our course along the side of the pond of St. Hubert, which we are about to cross. "They are drowned! they are drowned!" is the universal exclamation which we hear from every side as our balloon sails close to the water's edge. The best method of obtaining an accurate estimate of the population of any given district is to cross over it in a balloon: every soul rushes out of doors to look at you, and the people can be counted like marbles.

The good people of Essarts followed us along the sides of the vast pond of St. Hubert: the deepest curiosity was imprinted upon every countenance. We cannot say whether or not they were disappointed at the non-realization of their prediction, but the fact is that a small sack full of ballast was at this moment thrown overboard, and we rose to 1,640 feet at once.

The most curious experiment that can be made in a balloon when passing over a lake or other wide sheet of water consists in observing

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the beauty of the echo. No other surface is comparable in this respect with that of water, especially for the purity and sonority of the waves of sound that reach the ear. Every syllable that you may happen to address to the limpid surface comes back again with the utmost clearness and distinctness, whilst much louder noises are devoid of echo from the plains and fields.

Vast ponds lie to the west of St. Hubert. We leave the town and forest of Rambouillet to the left; at forty minutes past seven we quit the department Seine-et-Oise and enter that of Eure-et-Loire. At four minutes past eight the sun sets, its circular form being much disfigured by atmospheric refraction—the disc appears flattened above and below.

The winding course of the rivulet prevents our attempting a descent until we arrive at Villeneux. Already many hundreds of the country people have viewed us and are proclaiming our arrival by loud shouts. A handful of ballast thrown out enables us to pass over the village and to glide down quickly on the other side of it, near the gardens which join the houses to the open country. It is now seven minutes past eight, and we have travelled fifty-one miles, nearly in a straight line, from Paris.

The more important observations to be made on this excursion were reserved for our nocturnal expedition. They were to notice the variation of moisture and temperature with heights during the night; to observe the dawn of day at the summer solstice; the intensity of the moon's light; the brilliancy of the planets; the formation of clouds before daylight, &c. This part of the excursion was to be made alone with my accustomed pilot. But whatever pleasure may attach to those intellectual researches, the body must also be cared for, and requires substantial support. *Mens sana in corpore sano,* which, carefully translated, meant, "Let us go and get some supper at Dreux before our next ascent." Dreux was only two leagues distant, and we already got a glimpse of the sepulchral monument belonging to the Orleans family.

The inhabitants of Villeneux had been made aware of our intention, and took us along the principal street to the square. The streets here, as in similar old-fashioned places, are lighted by lamps swung upon wires across the road, which rendered the moving of the balloon a somewhat difficult undertaking. We were drawn along by means of a couple of ropes, and in two hours and a half we found ourselves at Dreux. The men who had taken us thus in tow declared that they were rather tired. But I proved to them, by means of algebra and the well-known principle of Archimedes, that they should not feel any fatigue, for

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the balloon weighs no more than its own volume of air. However, I dare not assert that they were convinced by this argument alone. A promenade of two hours and a half duration in a captive balloon, at eventide and in midsummer, is by no means a disagreeable adventure! and I cannot help thinking that the day will come when, instead of travelling across the desert on the uncomfortable backs of camels, the said dromedaries will have captive balloons attached to them, and the passengers provided thus with the most delicious mode of travelling it is possible to conceive. When we arrived at Dreux, we found that the balloon could not be got into the town on account of the telegraph wires. The men who had drawn us here were therefore requested to bivouac around it.

II.

The silver light of the moon streamed over the country, and the vast plane was completely still, as we left the hotel and proceeded to our aërostat, the car of which had been loaded with stones. The men had had no difficulty with it, for the atmosphere was perfectly calm, and the balloon had remained quite motionless.

As soon as it was delivered of the weight which kept it down, it soared quickly into the pure sky. My intelligent pilot poured out the ballast with a careful hand, keeping his eyes firmly fixed upon the barometer as he did so, whilst I gave myself up to contemplation and study.

We started at twenty-five minutes past one in the morning, just as the moon had reached the meridian; and at two o'clock we were 4,725 feet high: the thermometer had sunk from 50° Fahr. to 41°, the hygrometer from 97 to 84, after having stopped for a moment at a minimum of 79, when we were at a height of 2,625 feet. The variation in the degree of humidity, therefore, is not the same at night as by day.

The fact which struck me most during this ascent was the velocity of the wind, or the displacement of the air in connection with the altitude. Generally speaking, land winds (winds on the surface of the earth) are more intense *during the day* than the higher currents, but *at night* it appears that the higher currents are the strongest. But from want of a sufficient number of experiences I cannot yet assert that this is a general rule.

On the ground before we started the atmosphere was perfectly calm, but we had scarcely risen more than 328 feet when we perceived that we were being carried along at a considerable speed, which increased

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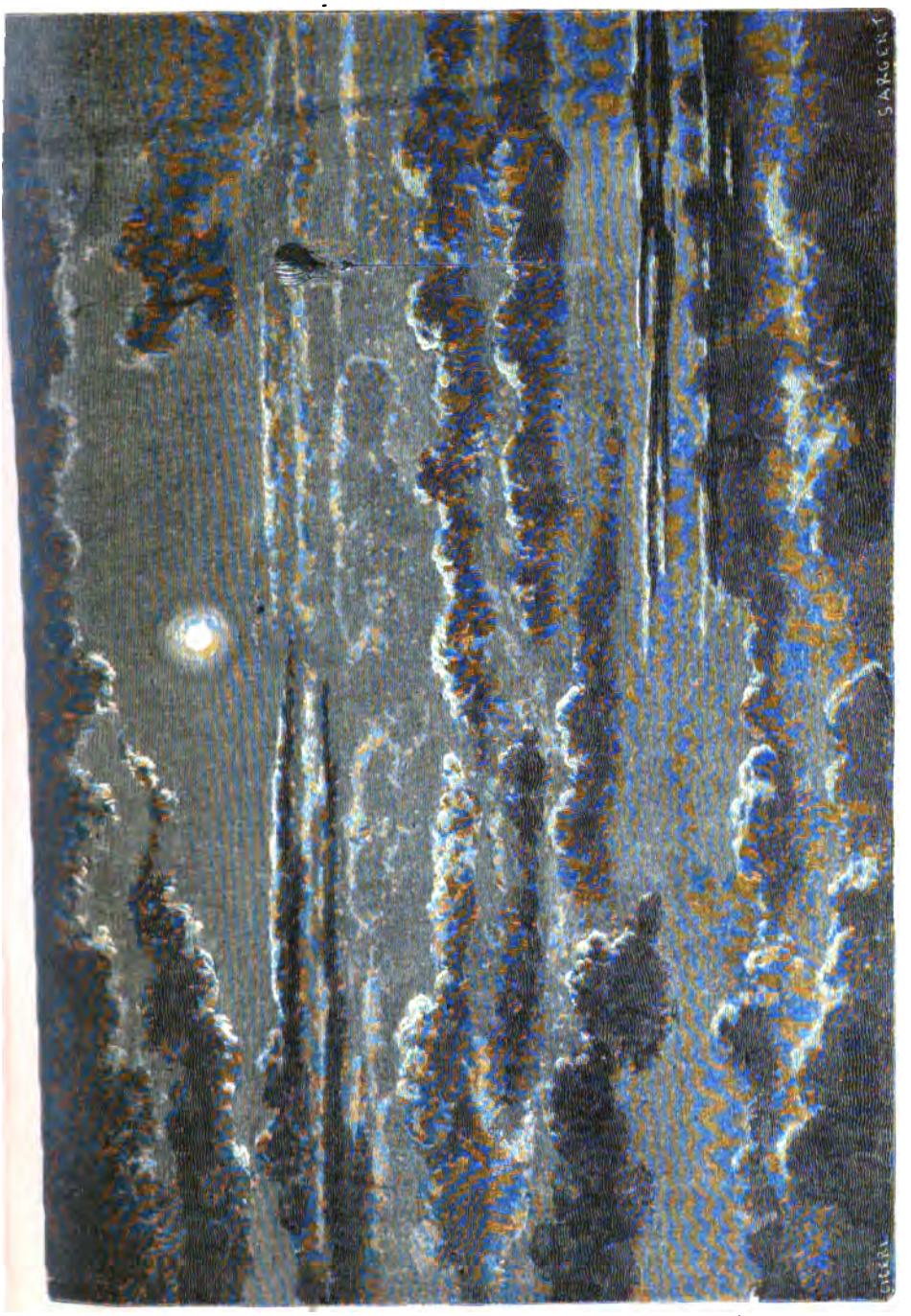

A MOONLIGHT EFFECT AS SEEN FROM THE BALLOON BY M. FLAMMARION.

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the higher we rose. This velocity was thirty-four feet per second during the first hour, and thirty-nine feet per second throughout the next. Moreover, the direction of our route was not the same as in the evening. I may observe that the aërostatic lines followed by balloons, or in other terms the currents of the atmosphere, often appear to form curves which tend to take a west or north-westerly direction.

At the summer solstice the commencement of dawn and the termination of twilight are very close together. We had scarcely quitted the ground, at half-past one, when we saw quite distinctly the first appearance of daybreak in the N.N.E. The white radiance of the morning aurora showed itself first on a thin horizontal zone of light, neatly terminated at about 15° above our horizon. I never saw a softer and purer light than this. What we were looking at was, in fact, the higher regions of the atmosphere lit up by the rays of the sun then just over the Mid-Pacific Ocean. The celestial whiteness of this approaching daylight was so exquisitely pure that the starlit regions of the sky, though so transparent, appeared as if covered with a leaden-coloured veil.

Some readers may think it strange that the first rays of dawn could be seen at half-past one in the morning in spite of the light of the moon. I was anxious to make this observation during the period of new moon, and on the 30th June, the sky being extremely clear at the time, I followed the faint twilight from eleven o'clock till one in the morning, and saw it pass gradually from N.N.W. to N.N.E. without ever disappearing entirely.[1] At this date the sun does not sink more than 18° below the horizon.

Being desirous of ascertaining the relative intensity of moonlight and the light of dawn, I compared them every five minutes. It was exactly at 2h. 45m. that both lights were of equal intensity, and then I could read a newspaper turned towards the morning aurora as easily as when it was turned towards the moon. But here a peculiar circumstance presents itself that may perhaps surprise our readers.

The whiteness of the light of the moon has become proverbial. When compared to that of candles, lamps, &c., the latter appears yellow or reddish yellow; the light of the moon causes even the flame of hydrogen to appear so red that the moon itself is almost blue by contrast. Thus the pale orb of night has become an emblem

[1] We have frequently made the same observation in the neighbourhood of London without the aid of a balloon, and in higher latitudes it is, of course, of common occurrence.—T. L. P.

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of purity, and the whitest lily cannot compare its tint to that of Phœbe.

I was therefore rather anxious to ascertain whether, when surprised by the advent of Aurora, the goddess of night was as pure as her reputation held her to be. The experiment was easily made, and the photometer used, one of the most simple kind: some sheets of white paper were exposed to the light of the moon, and then turned towards that of dawn, and this was repeated several times, to enable me to compare the tint and the intensity of the two sources of light. Now, some time before these two lights were of equal intensity, the pure white light of dawn had caused the other to turn distinctly yellow!

It is perhaps well to observe here that the notes taken in the balloon which form the skeleton of this narrative, were written sometimes by the light of the moon, sometimes by that of dawning day, and now and then more or less in the dark. For it is prudent not to carry any description of light in a balloon; the envelope of the latter being open at its lower extremity, the gas it contains may take fire by the slightest spark, and, it is needless to add, the aëronaut would be instantly precipitated to the earth.

The northern and southern portions of our heavens present two very different aspects. In the latter the sky is deep, transparent, and blue; the mist which covers the earth appears like an ocean of fog; the moon rides calmly above the world of watery vapour. In the former the sky appears covered or overcast, and, in the north-east, terminated in a transparent opening. Directly overhead hangs the enormous dark and apparently immovable sphere.

The principal spots on the moon's surface could be seen by the naked eye, even the radiating mountain Tycho; with a weak hand-glass I could distinguish the smallest spots. When I cast my eyes upon the fog below, and thought of the winds which range in these higher regions, it was not difficult to realize the difficulties which are met with in observing the celestial bodies from the lowest depths of the atmospheric ocean, and I could not help recalling the obstacles met with in this respect at the Paris Observatory, constantly surrounded as it is by the dust and steam of a large city.

At twenty minutes past two we sailed to the left of a little square town; at first sight we took it to be an orchard, but on examining it more attentively we recognized some large buildings and a promenade lined with trees. By referring to our map we made out that it was the town of Verneuil.

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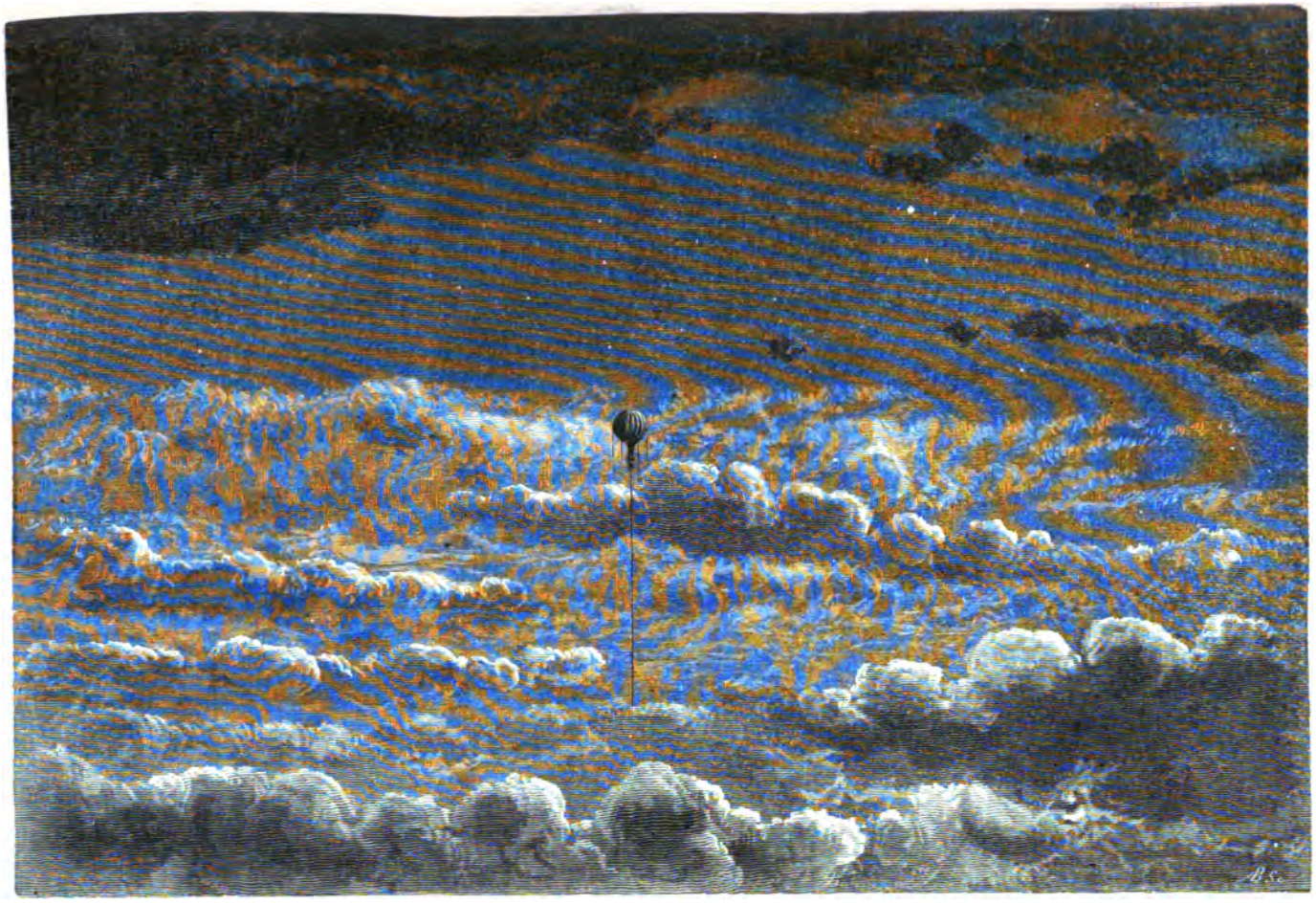

"BUT THE SCEPTRE OF THE NIGHT IS HELD BY JUPITER."

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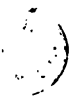

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At 2h. 55m. we pass over the town of Laigle. Deep valleys, in which a slight mist rises, are all we can see of its soil.

It was here, above Laigle, in the region of the air where we are now floating, that occurred the first fall of meteorites which was duly investigated by science.[1] It occurred on Friday, the 26th of April, 1803, a little after one o'clock in the afternoon, at a time when the sky was as clear as it is now. Thousands of stones are said to have fallen, and the celebrated Biot brought some fragments of them to the Academy of Sciences at Paris. Never did a fall of aërolites throw a country population into such a state of fright. Those who heard the explosion without seeing the light of the meteor, were astounded by this sudden production of loud thunder in the middle of a lovely day; those who saw the stones hurled down from the skies by some invisible power, falling with a cracking noise, on houses, on trees, and sinking into the soil, might well exclaim, with the ancient Gauls, that it was "the fall of heaven." Nothing less was required to draw the attention of French philosophers in those days to the wonderful phenomena of meteoric stones.

Our balloon passed through this region so celebrated in the history of meteorology, and continued its flight over the department of the Orne. Venus had just risen, and shines as a bright white star in the golden dawn, and with even a purer light than it. Mercury will rise too late to be observed. Mars sat before midnight. Saturn creeps down towards the west. But the sceptre of the night is held by Jupiter; I never saw this planet more brilliant, nor has it the slightest scintillation. It appears as bright as the moon, and all the stars, even those of the first magnitude, are pale in contrast with it. About three o'clock the stars become extinguished, one after another. Arcturus is the last to disappear; but the moon and Jupiter still remain visible, when the entire celestial army vanishes at the approach of day.

Since I made this first nocturnal excursion I have often passed the night in the air, as may be seen in the remainder of this narrative, but I never had such fine weather nor so charming an excursion. The temperature was 41° Fahr. at 4,921 feet above the earth, two hours after midnight (it was 50° on the ground); at half-past two it was 46°·4 at the height of 3,281 feet; at three o'clock it was 51°·8 at 1,312 feet, and therefore *higher* than that of the bottom of the valley into which we descended, and where the thermometer marked

[1] A complete account of this remarkable fall of meteorites is given in Phipson's "Meteors, Aërolites, and Falling Stars," p. 37 *et seq.* London, 1867.

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only 42°·8 half an hour later. Moisture was also now prevalent in the valley.

The luminosity spread through the atmosphere by the morning dawn is very different from the light of the moon. By means of the latter I could certainly read the indications of the various instruments and write, nor did we ever cease being able to distinguish the country below, the woods, fields, plateaux, and valleys. But this light *glides* over objects rather than penetrates them. It sketches their vague outline and produces a kind of semi-tinted map. With the light of the morning dawn nothing of the kind occurs; some time before it is equal in intensity to that of the moon, it fills the entire atmosphere and incorporates itself with its molecules. The air, the mountains, the valleys, all imbibe it; it *penetrates* the trees of the forest and the grass of the fields. Everything appears animated by it, and Nature seems to claim it as the universal cause of the life, force, and beauty of all created things.

At twenty-five minutes past three o'clock we came over the village of Gacé, and descended into a field covered with dew, at the side of the little river Touques, which falls into the sea at Trouville. Having allowed a little gas to escape, we came down to the ground, but we scarcely touched it. Some bullocks that were grazing near the spot appeared rather astonished by our descent, and after hesitating for about a quarter of an hour they approached the balloon. It was a herd of red bullocks; they inspected us for some moments, and then lowered their horns as if preparing for an attack. At this moment a bag of ballast was thrown at the head of the animal nearest to us, causing us to rise some twenty yards into the air, and to spring, as it were, to the other side of the field. No men came up until four o'clock, when some farmers approached and held the car down whilst we stepped out, surrounded this time by another herd of cattle.

The outspoken reflections which escape from the peasantry, men, women, and children, grouped around the car after we have reached the ground, are often rather amusing. Everything in or about the balloon is inspected by them with the utmost scrutiny: the scientific instruments seem to attract their attention in a wonderful manner. The mercurial barometer placed in its travelling case is generally taken for a telescope—"it is used to study the moon"—or sometimes for a gun. The hygrometer is taken for a clock or a large watch, and the reason given is "because the small hands of ordinary watches cannot move high up in the air." The aneroid barometer is always put down as a mariner's compass. Even an ordinary

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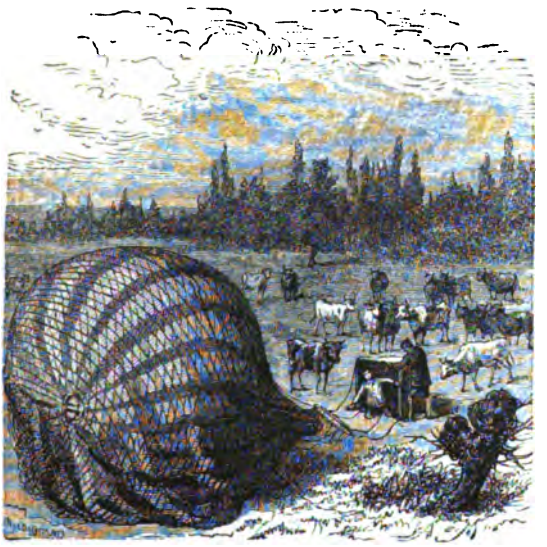
drinking bottle or wine flask is looked upon as some mysterious astronomical instrument, more or less connected with comets, meteors, and shooting stars.

After all, nothing equals the charm of these aërial travels, and at the end of every new excursion I cannot help regretting that this wonderfully easy and luxurious mode of locomotion cannot yet come into general practice. . . .



A DESCENT AMONG A HERD OF CATTLE.

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"THE LIGHTS OF THE EVENING FIRES WERE SEEN IN THE DISTANT VILLAGES."

CHAPTER VI.

FROM PARIS TO LAROCHEFOUCAULT-ANGOULEMÊ.—SIXTH VOYAGE.

As all the preceding excursions were accomplished in perfectly fine weather, I had not yet had the good fortune of passing through any layers of clouds and investigating the atmospheric world above them. The night on which I made my excursion into Normandy had passed so quickly that I was very desirous of passing a whole night in the atmosphere, even if the sky were covered with clouds, so that I might make a long series of observations sometimes above and sometimes below them. I began, therefore, to make preparations for this expedition. Contrary to my usually reserved habits, I must have incidentally mentioned my intention to some one, for I saw my forthcoming ascent announced in the daily papers. Now, it so happened that the *Giant* balloon, *awaking* from its long sleep, had also announced a scientific ascent, and not only were the papers filled with the advertisements of it, but the fact was placarded in every part of Paris.

The journals which had given some account of my previous balloon excursions were kind enough to hint that the two balloons would start together, and that the public were to witness a novel kind of competition.

It was arranged between the observers of the *Giant* and myself that the two balloons should ascend at the same moment, for the

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sake of noting the direction of the currents of wind. I therefore begged M. Eugène Godard to inflate our balloon by four o'clock precisely (the time mentioned on the aforesaid placards). A quarter of an hour elapsed, but no *Giant* appeared; another quarter of an hour had flown, and still no signs of the *Giant*. We waited fifteen minutes longer, but no *Giant* rose. This was too bad! Perhaps some accident had happened; but we could wait no longer, so at a quarter to five our beautiful aërostat rose above majestically into space.

The clouds did not appear to be very high, and, in order not to rise into them too rapidly, we carried plenty of ballast and ascended very slowly. The balloon veered towards the south, and afterwards towards the south-south-west and south-west. We passed straight over Grenelle, Vaugirard, Vanves, Châtillon, Fontenay-aux-Roses, Sceaux, Chatenay, and Antony. This northerly current appeared to be very general, and to extend to a very great height, for a balloon which rose with M. Louis Godard from Neuilly, and that of M. Nadar (the *Giant* above mentioned), both followed a course parallel to ours. The first fell at Clamart, and the second at Chilly, near Lonjumeau. As we passed over the Trocadéro and the site of the Exhibition we heard the people shouting, and we saw, not without some interest, the form of the *Giant* gliding as it were along the ground, whilst we had already risen nearly to the canopy of clouds above.

Whilst we admire the fine park of Sceaux, with its ponds and its green lawns, we find ourselves carried bodily into the clouds. Our height is 2,067 feet. The mercurial barometer of Fortin has sunk from 29·74 to 27·76; the thermometer from 68° to 59° Fahr.; the hygrometer has risen from 88 to 90, after having marked 85 at 1,080 feet. It is now twenty-seven minutes past five o'clock.

The balloon rises very gradually into the clouds. The atmosphere around us seems to become opaque, and the country below is seen as if covered with a thick veil, which is thicker in the centre than at the circumference. In a short time we can only descry the earth by looking in a slanting direction beneath, and we are now completely enveloped in an immense white fog, which seems to surround us, at a certain distance, like an ill-defined sphere, without coming in actual contact with us.

We also feel ourselves perfectly at rest in the midst of this dense and opaque atmosphere, for we can no longer perceive whether we move along horizontally or not, neither can we tell by looking at the fog whether we are rising or sinking. Suddenly, whilst we are thus suspended in the misty air, we hear an admirable concert of instrumental music, which seems to come from the cloud itself and from a

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distance of a few yards only from us. Our eyes endeavour to penetrate the depths of white, homogeneous, nebulous matter which surrounds us in every direction. We listen with no little astonishment to the sounds of the mysterious orchestra; then, turning to my meteorological instruments, I find that the humidity of the air *decreases* as we rise in the cloud, and that the temperature increases. At 2,297 feet the hygrometer has sunk gradually to 87, and the thermometer has risen to 62°·6.

A fog is much more sonorous than dry air, and collects sound with such intensity, that whenever, in passing through a cloud, we have heard a band playing in a town beneath us, the music always seemed to be close at hand. At the limit at which sound can be perceived through pure air, the interposition of a cloud, though it hides an entire town from sight, is far from weakening sounds; in fact, it may happen that such a cloud enables the aëronaut to detect slight noises which without it he would not have perceived.

We were serenaded by some excellent orchestral music whilst sailing over Antony and over Boulainvilliers; we were then entirely enveloped by clouds, and about 3,280 feet above each of these towns.

The silken globe of our aërostat slowly penetrates through the non-resisting cloud medium, and carries us into more luminous regions. Our eyes, which by this time have become accustomed to the dingy light below, are now keenly affected by the increasing luminosity which surrounds us. On all sides, above and below, the same white light envelopes us, and it is quite impossible to say on which side we have the sun. It is difficult to describe our situation at this moment: we are in the midst of a kind of white ocean, through which we are slowly penetrating. . . . But the light increases rapidly, and now the sun appears in the white sky like an immense beacon-light placed upon layers of snow.

Here we are again in broad daylight and with a clear sky. The earth lies far below us, underneath the veil of clouds; here we breathe in a bright atmosphere, radiant with light and heat, whilst the soil we have quitted seems shrouded in deep mourning.

When we were 330 feet above the higher surface of the clouds, we soared along in bright sunshine, and in a region to all appearance completely isolated from the earth; we seemed to be between two skies—the lower one appearing as if formed of white hills and valleys, variously toned and shaded, offering some vague resemblance to very finely carded wool, their size and depth diminishing gradually in the distance.

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"THE SUN APPEARS LIKE AN IMMENSE BEACON-LIGHT, PLACED UPON LAYERS OF SNOW."

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The upper sky was of an azure blue, across which were disposed a few fleecy clouds and white cirri, situated at a great height. We remained for a whole hour above the clouds, during which I sought in vain for words to describe the admirable and novel spectacle before us.

The shadow of the balloon was depicted upon the ocean of cloud, when it appeared like a second aërostat of a grey colour, sailing among them. It appeared deprived of all motion, for it was carried along by the same current which moved the clouds. The white hills and valleys beneath us appeared solid enough to invite us to step out of the car for a promenade among them.

At twenty-five minutes past six we heard a train leave some railway station, which, on referring to our guide, we found must have been that of Brétigny.

A small lady-bird (*Coccinella*) flew into the car of the balloon at this moment.

We rose gradually to a height of 6,230 feet; the clouds, which lay as a thick stratum at an elevation comprised between 1,640 and 2,950 feet, entirely hid the earth from our sight. Then a condensation occurred, and the balloon began to descend.

We remained until ten minutes to seven above the clouds, and to all appearance perfectly still. Such is the delicacy of the equilibrium of a balloon in the air, that when we sank a little below the upper level of the cloud stratum, ten ounces weight of ballast thrown out was sufficient to cause us to rise again into the blue sky. We did not sink again immediately, but at 6h. 50m. we penetrated downwards into the cloudy mass.

The effect was exactly the reverse of what we had just before experienced: first twilight, and then darkness, enveloped the solitary balloon; soon all was dark and dreary.

The condensation of the gas by the cold, added to our acquired velocity, caused us to descend now very rapidly, though we had never touched the valve-rope. In ten minutes we sank from a height of 6,230 feet to 2,460. In two minutes more we fell suddenly 2,130 feet, and as we quitted the lower portions of the cloud stratum *we saw the earth rising towards us with frightful rapidity.* Godard threw out ballast by sacks; and though this soon slackened our speed, we had nevertheless fallen to within 330 feet of the ground, and were just over Mesnil-Racoing, near Etampes. Balainvilliers was the last village we had seen through the clouds at 5h. 50m.; we had travelled eighteen miles in one hour above the clouds.

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The cloud stratum was 660 feet thick. At 3,280 feet in the air the hygrometer was at 74, and increased to 83 as we descended towards the earth. The thermometer marked 75°·2 above the clouds and in the sunshine, and 64°·4 below them.

At forty-seven minutes past seven we saw the sun once more; it then appeared like so much molten iron; and the clouds above which we soared now seemed like high transparent mountains, tinted by the yellow rays of the immense luminary. Small white cirri clouds still floated high in the air. At five minutes past eight the orb of day descended slowly into a sea of ruddy mountains of cloud.

Whilst we sailed along beneath the cloud level it was not yet quite dark, and from the country which spread itself out before our gaze rose a series of confused sounds, among which were the chirpings of mole-crickets, larks, and quails. When we soared into the pure sky, twilight enveloped us in its extensive radiance. Sometimes, as we descended somewhat towards the earth, the lights of the evening fires were seen in the distant villages.

At half-past eight, as we floated at a very slight elevation over Montigny and Teillay, we were observed by the inhabitants, some of whom asked us where we were going. "To Orleans." "All right," they replied; "you have only to follow the road; it 'is not more than five leagues; only, when you have passed the forest, you must turn a little to the right." "Thanks!"

We soon glided over the dark forest, and rose above the clouds again in order to take advantage of the last rays of twilight; we remained at this height until night had fairly come on, and I made observations every three minutes.

The twilight diminished slowly; all noise at the earth's surface had ceased, and the shades of evening had closed upon us.

To the north-west the sky remained faintly lighted by a vague, distant glimmer; the clouds had become more transparent, and from time to time the earth could be distinguished through the misty air.

It was then 8h. 55m. Our height was 2,300 feet, and the thermometer had sunk from 60°·8 to 53°·6.

A few minutes later we heard cries of "A balloon! a balloon!" which astonished us not a little, as we were then above the clouds; on looking down below, however, we found that we were in a little well of clouds, and the people at the bottom of it had remarked us through the opening.

We were then over Marigny. I hastily wrote a short despatch, dated from the skies, at 9h. 15m., and, having addressed it to the

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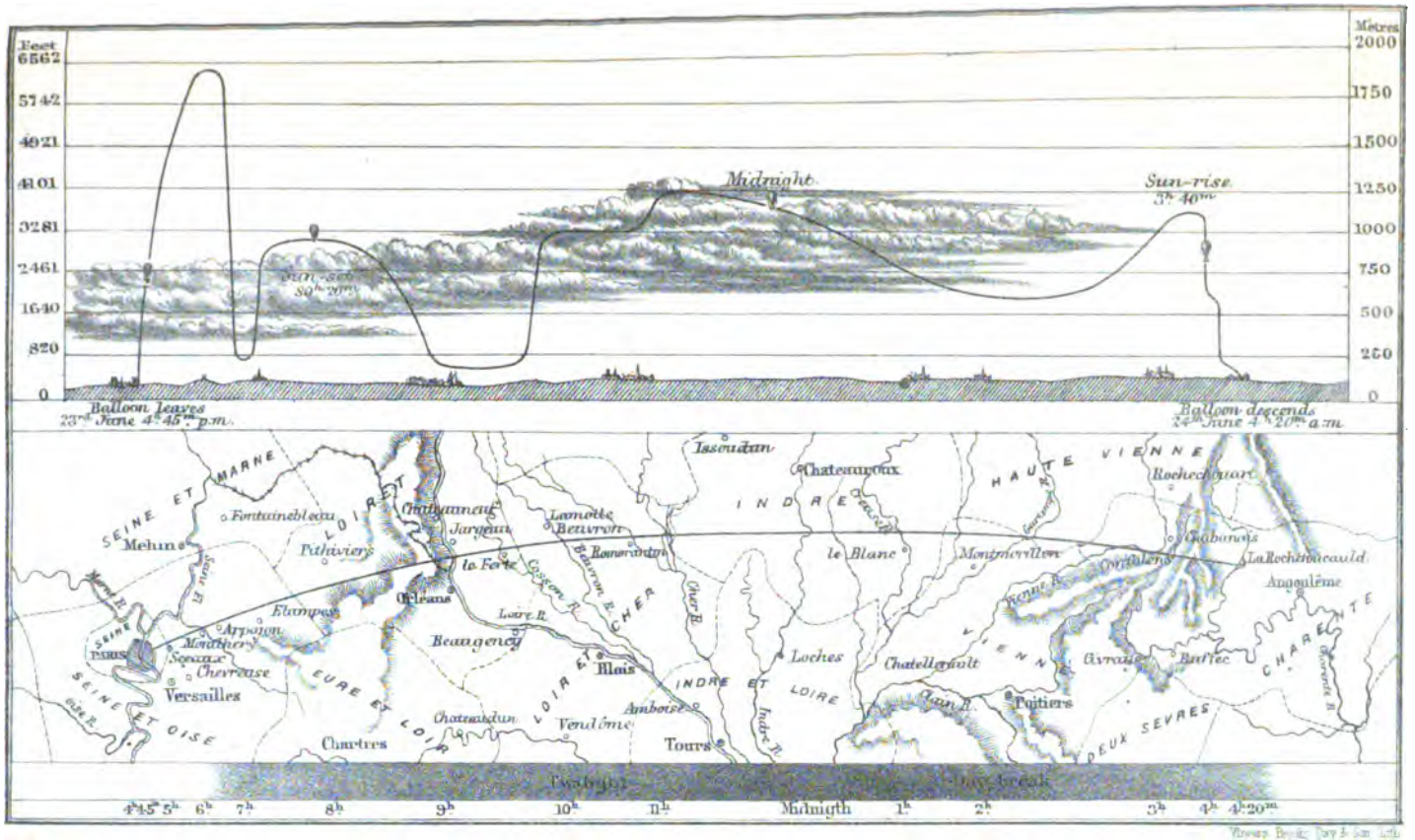

Course of the Balloon in M. Flammarion's ascent from Paris to La Rochefoucauld, June 23-24 1867.

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Orleans newspaper, I let it fall by means of a long ribbon of gilt paper. I cannot tell whether this aërial despatch ever reached its destination.

Before arriving at the river Loire we glided along from about nine o'clock within 330 feet of the ground. I fancied that I saw my written despatch fall into the river, for, in virtue of a well-known law of mechanics, an object falling from a balloon cannot follow a straight line to the earth, but describes an oblique course, in consequence of the balloon's motion. Well, whilst we were only about 300 feet above the ground, we not only heard, but could distinguish in the dusk the form of a carriage wending its way quietly along the road. Godard then took his speaking trumpet and shouted directly over the vehicle. The driver was exceedingly astonished, as may be easily imagined, stopped his horses, and, looking up, perceived the balloon. We exchanged a few words with him, and then sailed on in a south-south-west direction. It was then 9h. 40m.

From this moment we rose to the cloudy canopy above. Throwing out more ballast, we reached an elevation of 3,280 feet, and half an hour later 4,100 feet. Night had come on, and the sky was overcast. The darkness never prevented our being able to distinguish the country, the roads, the rivers, the ponds, and the woods; but from this time my notes were written by guess-work: it is not impossible to write legibly without seeing the paper.

In order to examine the instruments, I made use of a little glass globe which I had stocked with glowworms.

We passed over the Cher at eleven o'clock, above Romorantin, which lies between Tours and Bourges.

The night was cold and dark; the clouds formed a thick curtain overhead; the surface of the ground appeared as an immense obscure plain shaded with various dark tints. The only noise we could perceive was the constant croaking of thousands of frogs, and their concert lasted the whole night long, interrupted only now and then by intervals of silence or by the barking of watchdogs. The frogs indicated peat bogs and morasses, the dogs were evidence of villages; absolute silence told us we were passing over hills or forests.

About midnight we perceived fires here and there beneath us: they were those of the charcoal burners in the woods. These fires, seen from a distance, were like lighthouses, and the loud croaking of the frogs resembled most perfectly the distant roar of the sea. As we were certainly in the centre of France, we had no cause to fear the proximity of the ocean, besides which the compass marked our course as south-

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south-west. Since I made this journey, however, it has struck me that had we travelled in a current twice as rapid as that which carried us along, and had deviated somewhat to the west, we should most certainly have passed on to La Rochelle before daybreak.

A flash of lightning shot across the distant heavens; and the bulletin of the Paris Observatory for that day informs us that we narrowly escaped being swept along towards a violent tempest which rose from the Gulf of Gascony.

From time to time we heard the mournful sound of waterfalls; then silence intervened again, to be broken only by the harsh concert of the marshes.

A loud noise, which we supposed at first to be that of a railway train, reached our ears at half-past one: it proved to be caused by the flow of the river Creuse, which we passed over at Blanc, between Poitiers and Châteauroux.

All these various noises, which rose from the dark earth through the stillness of the night, were singularly intense, and astonished me not a little whilst investigating the transmission of sound through the atmosphere. Is it the universal silence which causes our ears to be more attentive? In my former excursions I had already noticed that sound is more easily transmitted from below upwards than in any other direction. I had connected with this the fact that at night the temperature of the atmosphere is more uniform, and consequently sound does not meet so many obstacles on its passage through it as it must do during the daytime, when it has to contend with a thousand various degrees of reflection and refraction whilst passing through the different strata.

Whilst referring to my notes of this journey, I recollect that the celebrated Von Humboldt made a similar observation on the borders of the Orinoco. He tells us that from a certain position on the plain of Antura the noise of the great waterfall on that river resembles the tumult of waves dashing upon a rocky shore; and he adds, as a remarkable circumstance, that the sound is much louder at night than in the daytime. This difference cannot be accounted for by the stillness of the night, for the humming of insects and the roaring of wild beasts render the night in those regions of the globe far more noisy than the day. Humboldt proposes the following explanation of it. Between the cascade and the position of the observer spreads a wide plain, the green surface of which has scattered over it a quantity of naked rocks: now, these rocks acquire, when under the influence of the sun's rays, a temperature that is considerably higher than that of the grass around; consequently a column of warm and light air rises

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"THESE FIRES SEEN FROM A DISTANCE WERE LIKE LIGHTHOUSES."

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above each of them. Hence it follows that in the daytime the sound of the waterfall has to pass through the layers of air, of very variable densities; and as each of the surfaces which limit these masses of air, whether they be denser or lighter masses, gives rise to an echo, the sound as it proceeds is necessarily weakened. During the night these variable temperatures cease to exist, and the rays of sound, propagated through a more homogeneous atmosphere, reach the ear without being diminished in intensity by a series of reflections. In optics we meet with an analogous phenomenon: light undergoes reflection when it meets the surface which separates two media of different densities, so that a succession of such media, though quite transparent, may become an obstacle to the penetration of light in consequence of the repeated reflection which it has to undergo along its course.

The monotonous croaking of the frogs ceases at two o'clock in the morning, and a few instants later the cocks crow in the various villages. It is still dark; but the familiar crowing of the cock is an agreeable sound after four hours of darkness and vague murmurs.

At 2h. 16m. we cross the Gartempe, near to Montmorillon. The sky is more overcast than ever. Dawn is not even perceptible yet, and spreads no luminosity through the air. At 3h. 10m. we cross the Vienne between Confolens and Chabannais, and we follow the course of the stream for some time. We distinguish a minute town, with a solitary oil lamp in the middle of it: it is Chabannais.

From midnight the balloon gradually sank from 3,280 feet to 2,625 at one o'clock, 1,640 at two o'clock, and 1,970 at half-past two. It had become heavier by the dew condensed upon it; the hygrometer oscillated around 93, and increased its indications after two o'clock. The thermometer marks 60°·8 Fahr. This rather high temperature must be attributed to the cloud covering above, which intercepts the radiation from the earth.

Jupiter and the moon are seen through an opening in the clouds; the light of the latter has come, now that we can almost do without it. This is the first time that I can see to write since ten o'clock last night.

The birds begin to sing at three o'clock, and daybreak dawns slowly upon us. Nature is rather late this morning. Nevertheless the inhabitants are early risers in these districts; already we can distinguish many figures along the roads. We are only 1,970 feet high, and we endeavour to hail them by means of our speaking trumpet, and inquire the name of their province. But all the reply we get is some words ending in *gnac*, which we fail to understand. At last we make out that we are at Confolens, in Charente.

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We have stepped over the mountain chain of Limousin, at its northern point, by means of the greater part of the ballast we had at our disposal, and the balloon now soars at an elevation of 3,940 feet. The beauty of the panorama spread out beneath us invites us to descend before the wind rises, so we pull the valve-rope for the first time at four o'clock, and sink to 1,640 feet; then again, and we are within 330 feet of the ground.

As we descend, the thermometer marks successively 60°·8, 59°, and 57°·2, showing that at this hour the air is colder in the valleys than on the plateaux. Whilst passing over a magnificent plain, slightly undulated, we got a glimpse of the towers of the old Château of Larochefoucault. A little lane between the cornfields and the vines wound along in our direction. We sank slowly down like a lazy bird; and it was not without a feeling of satisfaction that we breathed into our lungs the perfumed air of this wild country so far from Paris.

Godard was known at Larochefoucault from rather a singular adventure he had there. One day a balloon belonging to his brother fell near that town, but there was no aëronaut in the car; and on the seat a coat spotted with blood was found. M. Jules Godard had left Rochefort during a storm, and was obliged to descend immediately; but his balloon escaped by the force of the wind just as he was preparing to anchor it firmly, and he cut his hand accidentally with a knife just as this occurred, causing a few drops of blood to fall upon his coat. The Mayor of Rochefort instantly telegraphed to the different towns of the district, to know which of them had noticed the balloon; and I have before me the telegram in which the Mayor of Larochefoucault announced the dramatic arrival of the solitary balloon in his neighbourhood.

After we had admired the venerable ducal château, we started for Angoulême in a carriage drawn by a pair of beautiful horses; their course was less rapid but more certain than that of the balloon. At Rouelle we paid a visit to the Imperial foundries, where two large cannon of twenty tons weight were being made for the Exposition. In the evening the bonfires in honour of the feast of St. John were lighted all round Angoulême, and men and women were dancing before them and jumping over them almost all night. Among the recollections of Angoulême which I carried back with me, I may mention the irregular arches of the cathedral, the square tower, and the masonic lodge. But I can never forget being carried, standing upright, upon a single sheet of paper, at the well-known manufactory of Messrs. Lacroix Brothers.

The train which leaves Angoulême at four in the morning only

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arrives at Paris at eight o'clock in the evening; but we had come from Paris in the balloon in eleven hours and a half.

Our aërostatic course measured about 300 miles, which distance was accomplished between 4h. 45m. in the evening and 4h. 20m. of the next morning, or in eleven hours and twenty-five minutes: it is nearly thirty miles an hour (without stations on the road) on the average.

By referring to a plan of this journey I find that the greatest velocity was attained between 5h. 15m. and 6h. 45m. in the evening, precisely corresponding to the greatest height which we reached: and the line on the map which indicates the course which we followed is slightly curved; it forms an arc of a large circle. I have noticed this in other aërial excursions, and it naturally leads me to believe that currents of air do not perhaps travel through the atmosphere in absolutely straight lines, but that their course is always somewhat bent from left to right.

Had I been alone I would willingly have continued my journey on to Bordeaux and to the seaside, but my prudent pilot was afraid of the wind. And he was quite right, for half an hour after we had landed a violent gale sprang up and obliged us to let all the gas out of the balloon, contrary to our projects.

This long excursion was devoted principally to the investigation of the nature and physical constitution of clouds.

THE CHÂTEAU OF LAROCHEFOUCAULT.

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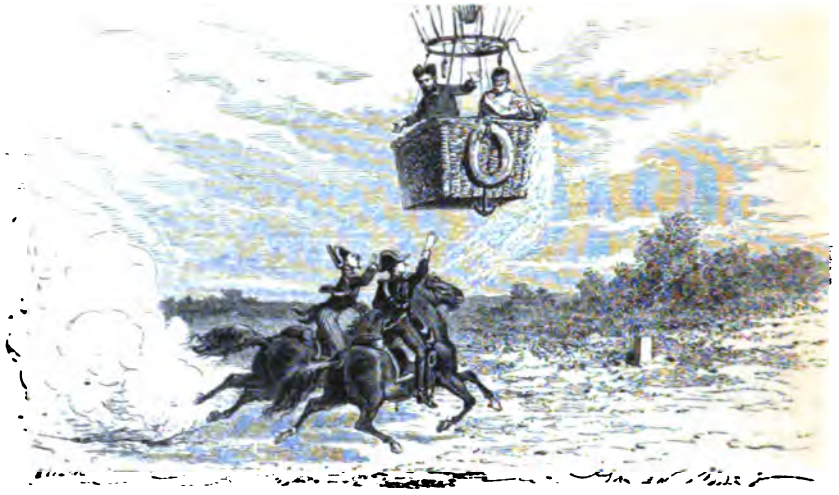

"YOUR PASSPORTS, GENTLEMEN!"

CHAPTER VII.

ASCENT AT SUNSET.

SOME time after my aërial trip from Paris to Angoulême, I made a short excursion through the atmosphere over the beautiful valley of the Seine, to the west of Paris. It was merely a promenade at a very low altitude, made with the object of studying the indications of the hygrometer, or the distribution of moisture in these lower regions. The sky was very fine, and the air calm; a very mild breeze, only, moved from the east-south-east, tepid and slow, like that which arises on the sea-shore as evening approaches. My aërial pilot on this occasion was, as usual, M. Eugène Godard, and we had offered a seat in the car to M. Victor Meunier, the editor of a scientific periodical. The balloon rose slowly from the west of the capital, as if carried up by some invisible hand. As we leave the earth, the Arc de l'Etoile is the first and last object which we see lit up by the golden rays of evening, whilst the city itself is hidden in the folds of a foggy atmosphere. From over the rond-point of Courbevoie we distinguish the statue of Napoleon, which is exactly beneath us, a quarter of an hour after our departure. As seen from above, it is rather difficult to recognize the Emperor; for perspective, like judgment, is singularly modified as the eye rises above the common level of men and things.

We are carried to the north-west of Paris, passing over Nanterre, Carrières-Saint-Denis, and Montesson; then our course inclines more

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to the north, and we come over the wood of St. Germain at Carrières-sous-Bois. We cross the Seine at Champ-Fleury and at Triel, follow its course to Vaux, and after passing (without any fatigue) over the rough hills of Evêquemont, we descend at Meulan. In this route of two hours at most, we have crossed the Seine no less than six times. Paris is still visible in the distance, and whilst over the wood of St. Germain we can distinguish very perfectly the form of the obelisk rising like a white needle against the green background of the Tuileries.

Our hygrometer, which marked 78 on the ground when we started, and 77 when we landed, was constantly between 50 and 54 on the journey. It fell to 56, 58, and 60 as we approached the hills which lie along the river Seine. Our height was never over 2,300 feet. About 6h. 45m. the shadow of the balloon became white, as I had previously noticed in our morning ascent over the Loire. On examining attentively the conditions of this phenomenon, I found that it is really due to the reflection of the solar rays from the dew-drops on the grass of the fields or the leaves of the trees, and that this occurs either in the morning or in the evening. When the motion of the balloon carried its shadow over the Seine, the latter became quite invisible. On the wood of St. Germain it appeared as an immense white aureola, the centre of which was occupied by a dark circle. I have received several curious letters with respect to this shadow, one of which, from a medical gentleman of St. Hermine, and another from a gardener of Frontenay-Rohan, attribute the phenomenon, rightly, to the dampness of the soil. The latter stated that if I had ever walked early in the morning over the ground covered with dew, I could scarcely have failed to observe the shadow of my head surrounded by sacred glory; and added, that as I had not taken holy orders, and was not very likely to do so, it was probable that, instead of seeking for an explanation of the fact in the "Lives of the Saints," I should look upon it as a purely natural phenomenon.

As we come near to the ground in making our descent, the aureola in question disappears, and is replaced by the opaque shadow of the balloon, which increases progressively in size, and approaches nearer to the vertical line which may be supposed to join our car to the earth. As the sun never attains to the zenith in these latitudes, and is most frequently at its average or mean height either before or after noon, the distance of the shadow of the balloon from the said vertical might, had we no better method, give us a rough indication of our height above the ground. The shadow comes in contact with us as we touch the soil. By observing the course of the shadow, some

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indication of the direction taken by the balloon may, in certain circumstances, be gained; but it is preferable to take this direction by observing the country directly underneath the car of the balloon.

As we approached the Seine, we sank obliquely for the space of ten minutes; the bright sun was reflected vividly in the water, and whilst passing over the river we leaned out of the car to witness the reflection of our own image; we had the satisfaction of seeing our red and distorted features pass slowly across the limpid mirror.

My friends have often asked me how we find out where we are at any moment during a balloon excursion. This is not very difficult. In a few minutes after we have left the earth, we see in what direction the wind carries us. After we have passed over the fortifications we see our route before us, and having with us an excellent map of the neighbourhood of Paris, we note the precise moment at which we pass over any striking object, such as a town, a road, a river, &c. When we get beyond the limits of the map of the Paris district, we take up one of the province over which we glide, or even a tolerably detailed map of France, and dotting each spot as we pass over it, we trace our route upon this map. Beyond the limits of the French Empire we could employ a map of Europe in the same manner; so that we always know where we are, where we are going, and with what velocity we proceed.

When clouds exist between us and the earth, the reconnoitring is a less easy task; we then judge from the last visible point which we noted, whereabouts we should be.

After having crossed the Seine we glided along at a very slight distance above the ground, and whilst I was noting down the indications of the hygrometer we were suddenly saluted from below with the words, "Your passports, gentlemen!" Who could send us such an extraordinary demand at this moment? The reader will already have queried—perhaps he has already hummed the air:—

"Deux gendarmes un beau dimanche
Chevauchaient le long d'un sentier."

For they were two gendarmes galloping along the road to St. Germain.

As there was a very good reason for our not throwing down our passports to them, Godard begged them to step up and verify them, emptying out a bag of ballast as he did so. The two police agents, as they continued their journey, doubtless meditated upon the modifications that would have to be introduced into the institution of the mounted police force as aërial navigation comes more into vogue.

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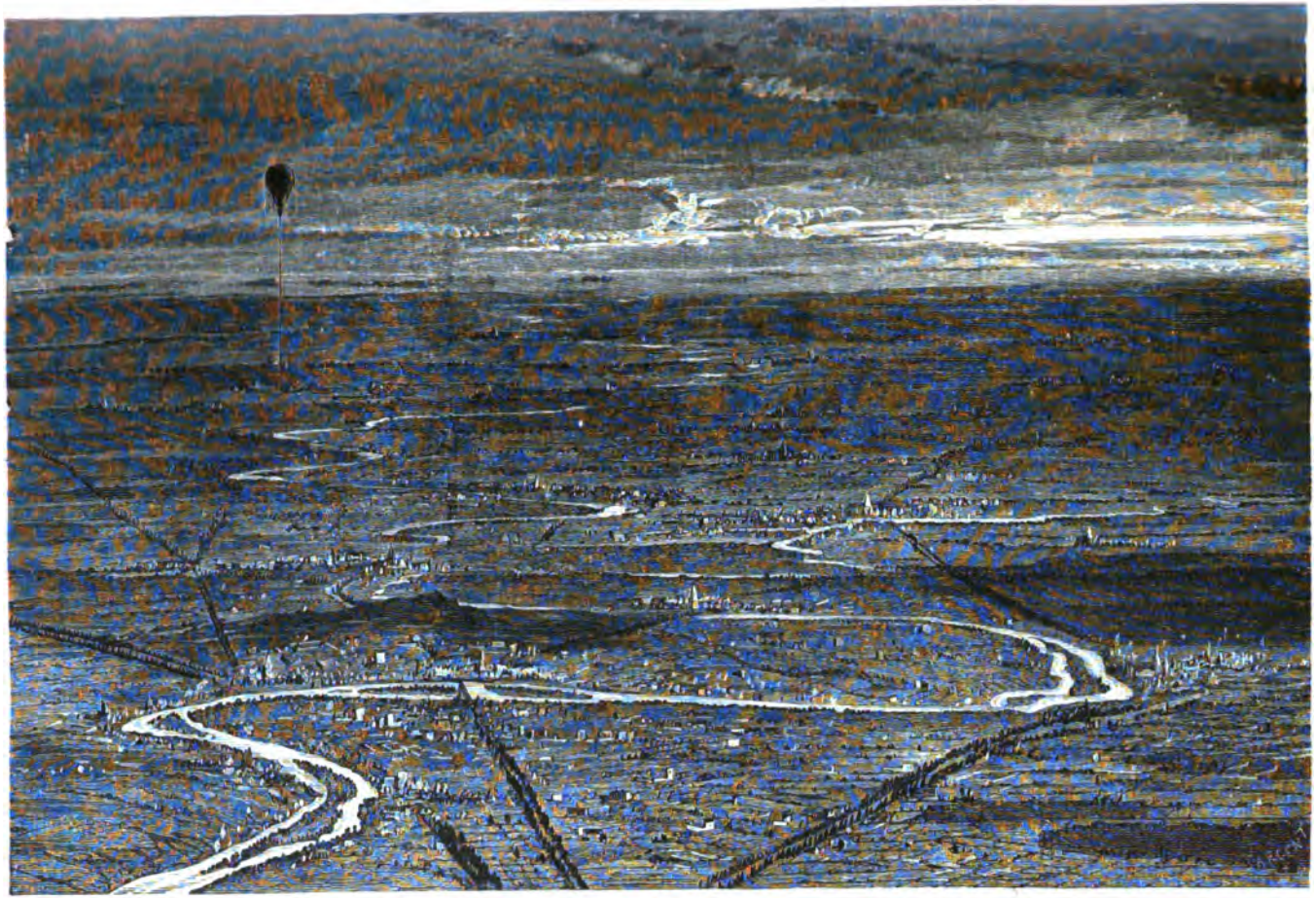

THE RIVER SEINE AND THE WEST OF PARIS—A VIEW FROM THE CAR OF THE BALLOON.

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Whilst we passed over the Seine at Treil and St. Nicaise, we repeated our experiments on the echo, and again observed how purely the sound of our voices was reverberated from the limpid stream, whilst the soil retained it and remained silent. As we passed over Vaux and other villages, the cries of "Eh! Flammarion!" told us that we were not exactly in a strange land.

We floated on at about 100 yards from the ground; our balloon did not adhere to the course of the stream, but stepped buoyantly over the hilly ground which borders it. We chose for our descent the picturesque route leading to Meulan, and, as Godard opened the valve, the people flocked out to meet us in great numbers. But it so happened that a breeze blew towards the town and carried us at once to its outskirts, whilst hundreds of voices proclaimed our arrival.

An incident that might have proved rather serious brought this excursion to an end. At the entrance to the town the inhabitants requested that they might pull us along to the central square. But to do this we had to be drawn over the wires to which the lamps hung across the streets. The first was passed without much difficulty, but on arriving at the second the narrowness of the street proved a serious obstacle to our passage. One of the cords rubbed along the front of a house from the windows of which many inquisitive heads were peering, and our car struck violently against a chimney. Some confusion arose, our orders were not punctually executed, and by some mistake the only cord by which the balloon was held down at this moment was let go. Thus suddenly delivered, we rose immediately over the town, to the great disappointment of the crowd, and were carried rapidly towards the Seine.

We managed, however, to descend on the opposite bank, in front of the *Ile-Belle*, in a beautiful meadow, where the entire population came out to meet us, and finally conducted us in a procession to Mureaux, where some gay and noisy festivities were going on.

The next day a long discussion ensued on the various methods of aërial locomotion—the means by which a balloon's course might be governed, the knowledge of atmospheric currents, flying by means of apparatus heavier than air, &c., and I was requested to give some account of the various opinions on these subjects; and to reply, if possible, to the question: *A bird flies; will it never be possible for man to fly also?* As this excursion has been a short one, I may append to it some account of the results of the discussion on these topics.

From the most remote period of antiquity men have made attempts, or have dreamt of doing so, to rise up into the air and to fly. Several

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persons have actually flown, but only over a slight space of ground, and generally by springing from a high place to the earth; the wings which they put on only served to support them a little, and to cause them to fall less abruptly and more or less in a horizontal line.

Up to the present day no one has been able to fly like a bird; that is, by springing from the ground and rising upwards. The attempts to which we allude have ceased; they were eclipsed by the brilliant discovery of aërostation, which furnished to man a new and unexpected method of rising into the air; and research was at once carried off in another direction—it was sought to govern and direct the motion of balloons, so as to travel as easily by their means above the ground as we do in the present state of things upon its surface.

The various trials that have been made, both in theory and practice, to direct the motion of balloons, have not hitherto been more fortunate than the attempts at flying just alluded to. A third method of aërial navigation has been brought forward in recent times, which is based upon mechanical considerations. It has been sought to navigate the atmosphere by means of machines essentially distinct in principle from balloons, heavier than the volume of air which they displace, and set in motion by powerful engines. This is doubtless the direction in which we must look for the future solution of the problem under consideration, unless, indeed, our knowledge of the currents of the atmosphere increases to such an extent as to render aërostatic navigation possible by their means.

A winged man, or a flying machine, will always be something heavier than its own volume of air. Let us, then, examine the mechanics of the flight of birds.

By what means does a bird rise into the air and direct its motion to any given point at will? Let us consider it fixed upon the ground and just about to fly off. The first motion is a slight spring whilst the wings spread out and embrace the air, and with a few flaps it flies off. The first start is assisted, no doubt, by the action of the bird's feet upon the ground and the striking of the air by the wings. If it happened that, when started in this manner, it could not bring its wings to act again upon the elastic air and so continue its flight upwards, the bird would fall to the ground at a very short distance from the spot whence it rose. As it is, the normal velocity of its flight is gradually acquired just as the region in which it is effected is attained.

How is this easy mode of translation through the air obtained? By the construction of the wing, which, being articulated to the fore part of the bird's body, may be compared to a lever in which the

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fulcrum is placed between the power and the resistance, but five, seven, or ten times nearer to the point of resistance than to the opposite point. By bearing periodically upon the air by the external portion of its wings, the bird proceeds on its flight in proportion to the effort made. The motive power of birds is that of all animated beings; the will in the first instance, and the connection of the muscular system with the nervous system and the brain, which is the seat of the will.

By the aid of science, man has supplied the place of the will by a mechanical power; locomotives and ships are moved by the regulated action of steam. The telegraph needle moves by the application of electricity. It is by the direct use of a similar agent that a machine will some day be caused to fly through the air.

In order to fly himself, man would have to make use of large wings which would require to be both very strong and very light. They would have to extend along the whole sides of the body, down to the ankles, and to be moved by the arms, at the extremities of which they would have their maximum breadth. It would be necessary also to ballast the body so as to ensure a horizontal position or to enable such a position to be taken when needed. All these precautions having been attended to, the winged man would weigh, I should imagine, about 250 lbs., and he must be endowed with enormous strength in order to make his way through the air by the action of the anterior rib of his wings. If such flying man had the strength necessary to flap the air with his wings four times per second, each flap raising him an inch and a quarter, he would possess the faculty of flight. But it happens that such a thing does not appear to be possible.

MM. Ponton d'Amécourt and Landelle have, by means of an ingenious spring apparatus, caused certain light substances to rise and remain in the air at a slight height as long as the action of the springs continued. We should have to substitute the weight of a man for that of these light substances, and the power of steam or electricity for that of the springs.

The greater the weight of an animal, the less, proportionally, is the spread of wing necessary to sustain it in the air, though the rapidity of the motion of the wings diminishes with the weight of the animal. A gnat expends in flying much more force, proportionally, than an eagle. If a man construct an apparatus for flying, he soon finds that the force to be expended decreases in proportion to the size of the apparatus.

In most insects the motion of the wings is so rapid as to be quite

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invisible. M. Marey has recently endeavoured to represent the form and the velocity of these motions. In order to determine the frequency of the beats, an *acoustic method* may be made use of, which enables us to judge, by the sound produced during flight, of the rapidity of the vibration. Most insects produce whilst flying a more or less acute buzzing sound, the pitch of which may be ascertained by means of any musical instrument, and this should, it seems, give us the number of beats of the wing per second. A more efficacious, though somewhat cruel method, consists in sticking the insect to a cork, and allowing the extremity of the wing to strike against the smoked surface of a revolving cylinder. By comparing the trace thus produced to that given in the same circumstances by the vibrations of a tuning-fork, the note of which is known, the exact number of beats per second may be obtained. This number is 330 for the common house-fly, 290 for the bee, 140 for the wasp, 70 for the common moth (*Sphinx vespertilio*), 28 for the dragon-fly, and about 8 for the common butterfly. These numbers represent the *double* vibration, *i. e.* the rise and fall of wing reckoned as one beat.

With regard to the flight of birds, M. Liais, formerly of the Paris Observatory, is of opinion that the wing meets with no resistance as it rises. As the bird lowers it, the wing is rather bent backwards, so that the resistance of the atmosphere to the progressive motion tends to support the bird in the air: when the flapping of the wing commences, the latter is not brought down parallel to itself, but lowered, more especially at its anterior border; it is then soon carried backwards, so as to accelerate the progress forward and counterbalance the effect of gravitation at the same time. Towards the end of the motion the hind part of the wing comes promptly forward with an increased velocity, and arrives a little below the anterior portion, as immediately before the beat. It results from this, that as the wing is lowered the whole force developed is employed to counterbalance gravitation, whilst the middle portion of the movement is devoted also to increase the horizontal motion of the bird.

Whilst the wing rises it constantly preserves the inclined position towards the hind part of the bird which it has acquired; and if we take into account the horizontal progress made whilst the wing rises, it is easy to perceive that the latter experiences resistance only on its narrow edge. In the flight of birds and other flying animals the phenomenon of reaction overcomes the various resistances. Thrusting downwards a certain volume of air by means of its wings, the body of a bird acquires a certain rebound, such as we observe in a piece of cannon when fired, or a sky-rocket.

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Some mathematicians, in endeavouring to ascertain the amount of work done in the act of flying, have effected their calculations on an erroneous basis, and have found, amongst other absurdities, that a bird the size of a goose must, in order to support itself in the air, execute work equivalent to that of two horses; when we all know that the strength of a child is sufficient to stop the motion of the wings in a bird of this size. No doubt animals that fly have very powerful muscles for moving the wings from above downwards, but that does not prove that a great amount of work is necessary to support them in the air. These muscles are powerful because they must be capable of providing a sudden effort, but they are not required to repeat it continually. After every development of force comes a long period of repose, so that the total amount of work done is exceedingly small.

The muscles which raise the wing are, on the contrary, very weak, because it rises slowly and in the circumstances alluded to above.

Instead of calculating the quantity of work done, it is preferable to measure it as M. Liais has done, by taking the weight of several kinds of birds, measuring the surface of their wings, the velocity of progression, &c. The general result of this research has been to show that the quantity of work necessary for flight is represented per second by less than one-third of the weight of the bird or other animal raised to the height of one yard, and that the ratio of the weight of the bird to the surface of the wings increases with the span of the latter. The last fact shows that the larger the animal the easier is its flight when once in the air, but small birds rise easier from the ground than large ones.

To rise from the ground, a bird must spring. Now, as their strength is nearly proportionate to their size, and as the quantity of work necessary to accomplish a bound of a given height is also proportionate to the weight, it follows that all birds, whatever their size, spring nearly to the same height. But the extent of spring accomplished by the smaller species is sufficient to enable them to flap their wings without bringing them into contact with the ground: this is not the case with larger birds, such as the eagle or the albatross, and the latter are obliged to run for some distance along the ground before they can rise. When they have thus acquired a certain amount of horizontal velocity, they suddenly open their wings as if to soar, and the extended surface tends to counterbalance the effects of gravitation. It is at this moment that they spring, and rise at once to a sufficient height to flap their wings. Many large birds, such as the eagle and the condor, generally avoid settling on the ground, and remain perched on high rocks, from whence they can easily soar into space.

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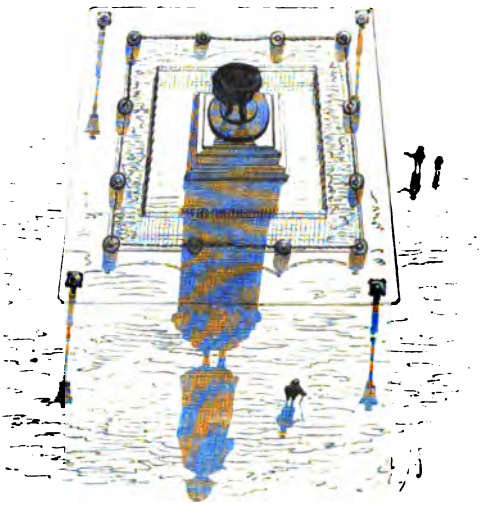
The conclusion of this dissertation may, then, be summed up by stating, that men will some day or other fly through the air, not by means of their own physical strength, but by means of some winged apparatus (or helices) set in motion by some powerful physical agency such as steam or electricity. In the meantime let us continue the narration of our balloon excursions, and relate our aërial journey into Prussia.



THE STATUE OF NAPOLEON AS SEEN FROM ON HIGH.

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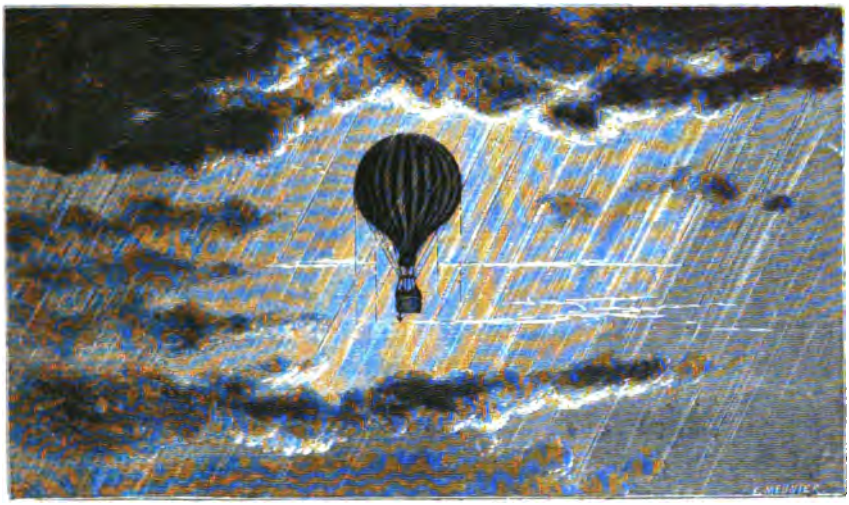

RAIN IN THE HIGHER REGIONS

CHAPTER VIII.

FROM PARIS INTO PRUSSIA, BY ROCROI, AIX-LA-CHAPELLE, AND COLOGNE.

THOSE sciences which depend solely upon observation can make but slow progress. Meteorology, more especially, is a long and complicated study, the elements of which are far apart and transitory. Those who suppose that an hour's observation is sufficient to enable them to become acquainted with the principal phenomena of the atmosphere, evince little knowledge of scientific methods. Days, weeks, and even months may elapse before the most attentive observer is rewarded by an insight into the laws of the phenomena which he subjects to investigation.

The ascents described in the preceding pages were very different from each other, inasmuch as they are each characterized by a particular state of the weather. The present one, made on the 14th July, will be found also to differ essentially from all the others. The sky had been rainy during the forepart of the day; our balloon itself had been wet by a shower from two to three o'clock, and rain fell upon it again at a quarter past four. We started at 5h. 22m., the weather being very cloudy after a thunder shower, and with a fine breeze blowing.

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We passed perpendicularly over the Arc de l'Etoile, and in less than five minutes soared over the country of Montmartre. We are already 2,461 feet high. We have left St. Denis to the left, and we perceive a light cloud hanging over Paris, but not reaching to the ground. This time it is not a vast body of dust that we see suspended over the capital, but a real cloud. Soon the great city disappears from our gaze, so rapid has been our departure. The high tower of the stately church of St. Denis, the last resting-place of French kings, which Louis XIV. gazed at from the tower of St. Germain, also flies away from us with astonishing rapidity.

To our left we noticed the village of Gonesse. Here it was that the *first* balloon fell, which left Paris from the Champ de Mars on the 27th August, 1783. Nothing in the shape of a living being occupied the car of this balloon, which was inflated in the workshop of the brothers Robert, in the Place des Victoires, under the superintendence of Professor Charles. It had been brought through Paris by night, and reached the Champ de Mars by torchlight, much to the astonishment of the people, who had never witnessed such a spectacle before. We have already alluded to this ascent. When the aërial globe had risen to a great height, the envelope burst and the gas escaped. The balloon then came down very rapidly, and fell at Gonesse, striking terror among the inhabitants of this quiet village.

They ran in a crowd towards the monster, and two monks having asserted that the skin was that of some fabulous animal, stones were thrown at it and pitchforks stuck into it by the peasants. It is even said that the curate of Gonesse determined to exorcise the wonderful beast, and a procession of country folk marched out towards it. Taking a most circuitous route, and muttering many prayers, they at last came near the spot where lay the semi-globe, vibrating and shuddering with the slightest breath of wind. But they approached it very slowly, in the hopes that it would fly off again . . . . At last the bravest among them, whose name history has not brought down to us, fired a gun at it. The charge of shot, tearing the envelope still more, caused the remainder of the gas to issue and the balloon to flatten down completely. At this moment every one rushed forward to give the terrible monster the *coup de grâce*, but the stench of the gas which issued from the wound caused the most enthusiastic to fly back again. Finally the palpitating remains of the victim were fastened to the tail of a horse, and dragged five hundred yards across the fields.

The next day the Government, in order to prevent a repetition of such scenes, published a "Notice to the public on the ascent of balloons into the air," in which it was explained that they are not

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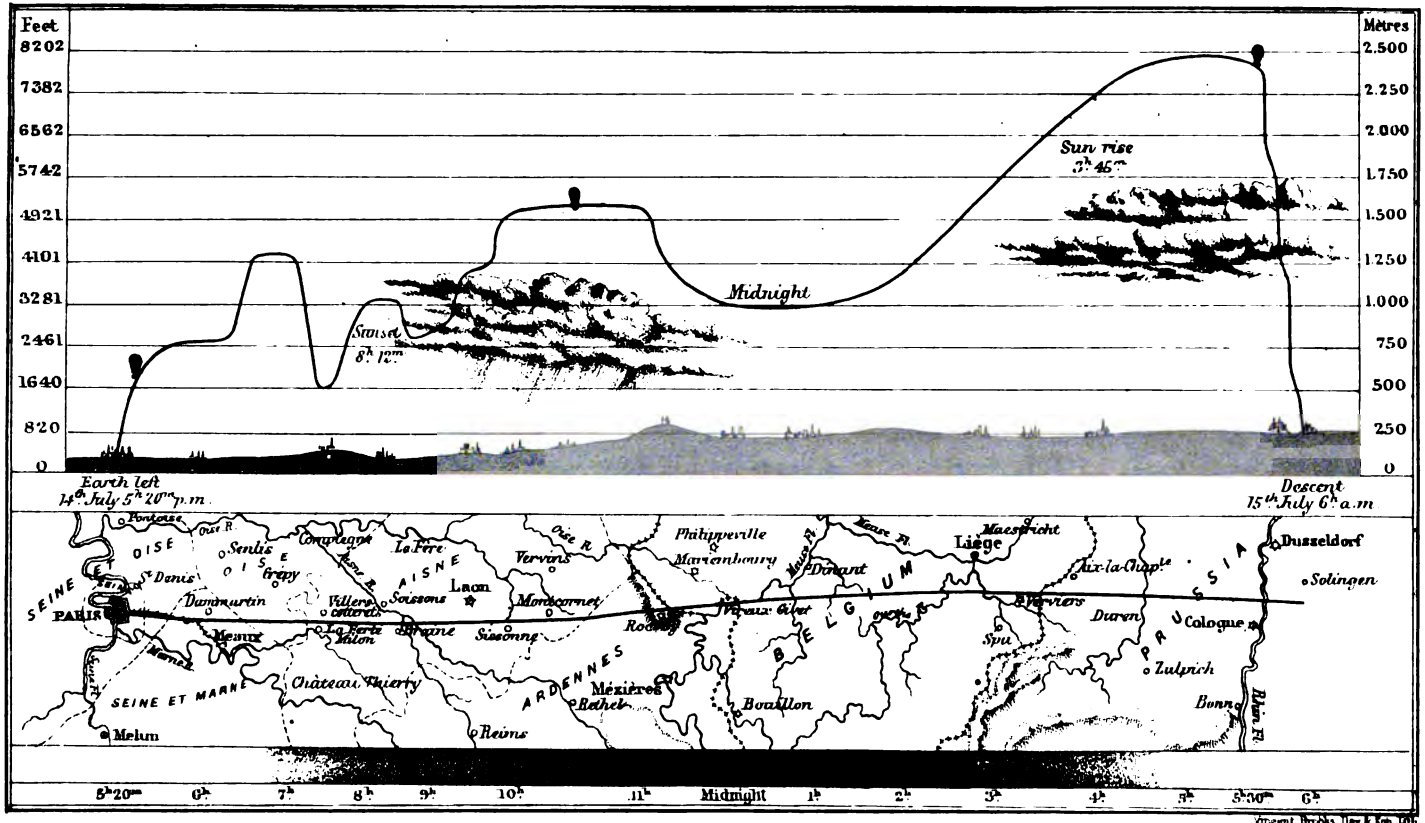

Course of the Balloon in M. Flammarion's ascent from Paris to Solingen in Prussia, July 14-15, 1867.

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wild beasts, but merely globes of silk inflated with gas, which is lighter than air, and that it is necessary to study their movements in the hopes of rendering them useful to society.

Whenever we pass over a village the geese invariably cackle and the dogs bark; no bird ever approaches the balloon in the air. There can be little doubt, therefore, that our aërial machine either frightens or astonishes every living being.

We glide on in a north-easterly direction between two zones of rain, one to the right of us and the other to the left. The rain which falls in the sunshine forms an oblique white trace in front of the darker-coloured clouds which form the background; whilst that which falls in the shade is seen as grey lines upon a background of whitish cloud beyond. Drawings of the rain-clouds and the oblique rain are easily executed; for these clouds are above us, travelling more rapidly than we do, and in the same direction.

The humidity of the air, which diminished at the commencement of our ascent, now increases gradually: we had 71 on the ground before starting, 67 at 5h. 27m. at 1,640 feet of elevation; and 66 at 5h. 40m. at 1,960 feet. At 6h. 22m. it was 77 at 1,345 feet; then decreased to 73 at 2,133 feet, and 70 at 2,690 feet, which occurred at 6h. 35m. The thermometer, which indicated 71°·6 Fahr. on the ground before we started, gradually sank to 59°.

At 6h. 15m. we are over Thieux; six minutes later we cross the railway at the Maras station, and we leave Dammartin to the left. As we pass, soon after, over Noéfort, I notice on the map, as lying to our left hand, the names of places which should recall a terrestrial paradise—"Eve," "Eve's Mount," "The Bridge of Eve." They may be very pretty places, but we cannot stop; already we can perceive the town of Laon on its high plateau; it is not upon our horizon, but stands out in black upon the grey background of the immense plain beyond. Laon is forty-eight miles from here.

Rain is falling all along the north and north-west region, and we have not had a glimpse of the sun since we started. This, on the whole, is fortunate, for if by the heat of the solar rays the balloon were to be much dilated, the rain, which threatens us and will probably reach us before long, would doubtless bring our projected journey to an abrupt termination during the night.

After sailing from 5h. 40m. till 6h. 30m. at a height of 2,460 feet, we lighten our weight by throwing out a few pounds of ballast, and rise to 4,265 feet.

We now enter the Départemente de l'Aisne, and can perceive the boundaries of the forest of Villers-Cotterets. From time to time a

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gun is fired at us; we trust it is merely intended as a salute. The smoke of the discharge blows away to the north; there exists, therefore, an oblique current below us on the earth's surface. I have rarely observed any difference of currents except over the undulated country of the Loire Inférieure. Over a flat country I had not before noticed the fact.

A curious meteorological phenomenon was observed on the forest. For some time past we had noticed small light clouds situated far below us, suspended as it were over the summits of the trees, and perfectly still. When we came over the largest of them we found that it was a cloud situated some 200 to 300 feet above a pond. It was completely isolated, and might have been some 330 feet wide and 70 feet thick; but what struck us most was its absolute stillness. Was there no breeze blowing along the ground? or did the wind take the form of a cloud as it passed over the pond of water? This we were not able to decide.[1] Other small clouds were seen in like manner along the course of a rivulet. It is difficult to believe that whilst we were progressing at the rate of 36 feet per second, at an elevation of only 1,640 feet, there could be no breeze whatever along the surface of the ground.

The humidity of the air has varied in a very complicated manner. At seven o'clock the hygrometer marked 80, at a height of 2,690 feet; at 7h. 10m., 85 at 2,428 feet; at 7h. 30m., whilst over the forest, 90 at 1,640 feet; and at 7h. 43m., at a height of 2,953 feet, we had 85. The thermometrical indications are more regular: we had 50° Fahr. at 3,084 feet; 53°·6 at 2,461 feet; and 59° at 1,476 feet.

We sail between distant zones of rain. The smoke which precedes the rain is driven with great force in the direction of the rain itself: it is the only forerunner which occupies the space between the clouds and the earth. The smoke, which is nearer to us, and alongside of the rainy zone, seems to be attracted to this zone, and forms a right angle with the former.

At eight o'clock the sky presented a magnificent spectacle. The sun, hidden by the higher clouds, lit up the rain, making it appear like molten metal. It had something of the appearance of an immense Bengal light burning on the ground and rising directly behind the clouds above. In a few moments the whole of Nature was illuminated and vigorously coloured by this curious glare. The summits of the

[1] This phenomenon is probably analogous to that of a cloud suspended in the air or resting on the top of a hill, when the wind is blowing strongly. The cloud appears stationary, but its particles are undergoing constant change and renewal.—Ed.

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distant hills, and the clouds above, were alike tinted with the red light.

In a short time the sun burst forth like an enormous sphere of red-hot metal, between two lines of ruddy clouds. But at ten minutes past eight we had lost sight of the orb of day, and continued our journey in the twilight.

Whilst partaking of our dinner we made an experiment, which consisted in filling a tumbler with water to the very edge of the glass, so that it would have been impossible to add another drop of liquid without causing it to flow over the sides. We wished to see whether the oscillations or any other motion of the balloon would cause the tumbler to overflow. Nothing of the kind occurred, though our aërial sphere was travelling with the rapidity of a locomotive, and with vertical undulations of several hundred yards; not a drop of water left the edge of the glass.

Another mechanical experiment was made in the evening, and renewed next day. I wished to verify Galileo's principle of the independence of simultaneous motions. According to this principle, a body which is allowed to fall from another body in motion participates in the motion of the latter; thus, if we drop a marble from the masthead of a ship, it preserves during its fall the rate of motion of the vessel, and falls at the foot of the mast, as if the ship were still. Now, if a body falls from a balloon, does it also follow the motion of the latter, or does it fall directly to the earth in a line which is perpendicular to the point at which we let it go? In the first case, its fall would be described by an oblique line. The latter was found to be the fact, as we proved by letting a bottle fall. During its descent it partakes of the balloon's motion, and, until it reaches the earth, is always seen perpendicularly beneath the car.

In falling, the bottle produced a very loud hissing noise, owing to the resistance of the air, and similar to the noise made by a musket ball when it passes violently through a layer of water. We were not able to follow the bottle until it reached the earth, for the white paper in which we had enveloped it was torn away from it in its rapid descent.

About nine o'clock night succeeded to the twilight. The black clouds which had followed us since our departure now overtook us, and the sky, which below us had been hitherto inoffensive enough, now begins to fill with the threatening mists. The moon, which should have risen at six o'clock, has not yet shown her pale face; on the contrary, the sky has become blacker than ever. Suddenly we find ourselves enveloped in darkness. We had hoped all along

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that our progress would have been more rapid than that of the clouds, and that we should have outstripped the storm.

At 9h. 15m. thunder. At 9h. 20m. the heavy rain falls with a crackling noise upon the balloon. As there is now no doubt whatever that the storm has overtaken us, we decide upon doing what appears best (and what can only be done in a balloon), namely, to rise above the clouds which are drenching us with rain. My pilot, having arranged everything in case we should be obliged to make a rapid descent, throws out one measure of ballast, and we rise through the rain-cloud to a height of 3,937 feet. But it seems that this is not sufficient! The cloud comes again upon us. We throw out more ballast, pound after pound, and rise to 5,578 feet, and here we are quite free from the troublesome weather. Indeed, it is quite essential not to get wet, if we are to make a long journey. In such circumstances the balloon might, in the course of a few minutes, collect enough water to weigh it down and cause it to sink to the ground, which would be a very disagreeable occurrence in the middle of a dark stormy night. When we got above the stormy nimbus, we heard the rain falling underneath us for at least half an hour.

The rain has ceased, and the country is now visible beneath us. And what is this brilliant light and that noisy festivity which we perceive down below, whilst the sounds of an orchestra playing dance-music reach our ears? It must be a very large room, and is probably some public ball—they appear to be amusing themselves.

We have just passed over the little town of Sissonne. We must have passed Laon on our left during the rain. At present we are making for the Ardennes. Will not its high plateau covered with woods, and its chains of hills, reach up to our balloon? No, we shall bound over them with some five or six hundred yards to spare.

It is now eleven o'clock, and our height is 5,247 feet. The thermometer marks 50° Fahr. and the hygrometer 93. We have passed over woods and mountains. The moon, which had "eaten up the clouds," is again hidden behind a thick veil, and rain appears to be falling once more to the east of us. We are still plunged in absolute silence, and in the midst of this solitude we feel we are the only living beings who are at this moment passing through the regions of night and sleep.

But what is that stony star just below us, shining amidst the dark foliage of the earth? Is it a fortress on the frontier? Is it a town surrounded by bastions and ramparts? We pass perpendicularly over it, but cannot distinguish the vestige of a light. Nevertheless, we see long rows of houses inside the fortifications, and large squares evidently

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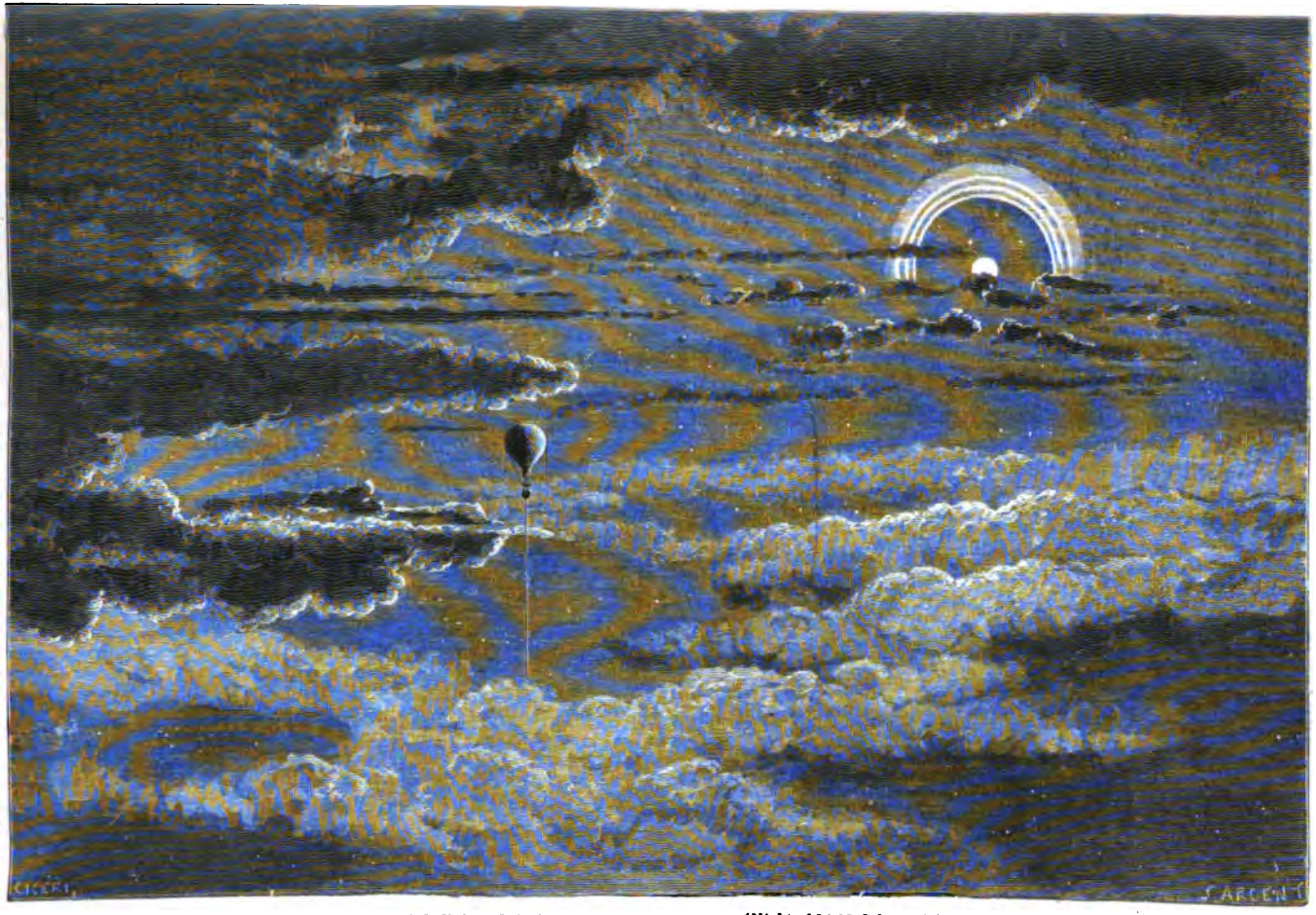

LUNAR HALO OBSERVED BY M. FLAMMARION. (*Night of* 14-15 *July*, 1867.)

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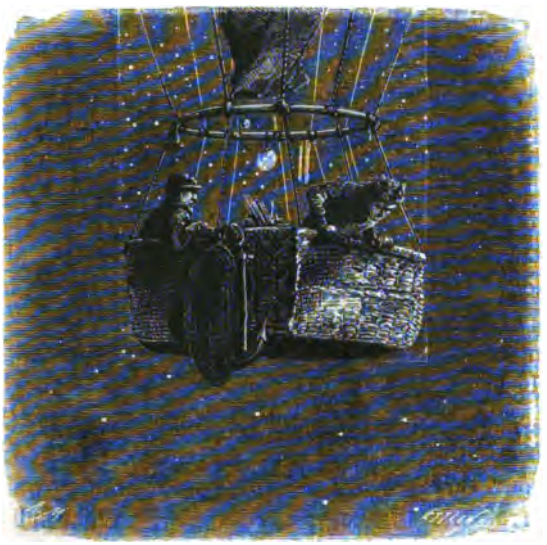
intended for exercising troops. It is Rocroi. We shout to the custom-house officers, but in vain. At the height at which we are sailing, what voice, were it equal to that of Lablache himself, could reach down to the earth? Carried along by the wind, we have passed the frontiers, which have no existence for us, and we now soar over Belgium.

The moon at last shines forth. Small light clouds fly from time to time before its disc, but do not intercept its silver rays. Around the moon a curious aureola is vaguely seen, and very soon a magnificent lunar rainbow spreads itself out above the lower disc. We can only distinguish three colours in it—red, green, and violet; and even these are only faintly visible. An instant later, instead of being above the moon, the semicircle is seen below it. It is a *lunar halo*, an optical effect well described by Arago in vol. xi. of his "Œuvres," and must not be mistaken for the phenomenon known as a "lunar rainbow."



A GLANCE INTO SPACE BELOW, AT NIGHT.

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THE BANKS OF THE MEUSE.

CHAPTER IX.

FROM PARIS INTO PRUSSIA (*continued*).

It is now midnight. We are the only aërial travellers plunged in the depths of space, and surrounded by silence, solitude, and darkness. Our conversation alone breaks the monotony of this dreary region, and the sound of our voices in these dark heights seems something derogatory to the laws which govern the world. The grey clouds roll along the immense vault, and fly, like armies of light phantoms, into the depths of the night. After a while the silver rays of the moon gleam forth, and their soft light fall upon our aërostat.

Below, an unknown landscape is indistinctly sketched. France has gone from beneath us. We are now sailing over Belgium. I note carefully the indications of the various instruments. Our height at midnight is 3,280 feet. We shall soon be higher. Whilst I write these lines our ears are assailed by the noise of a waterfall, which breaks the profound silence of our journey. We bend over the car to reconnoitre the country below, and we find that after passing over a small stream we have come upon a larger one, which can only be the Meuse. We follow its sinuous course for some time. Beautiful river, I welcome thee! Near thy banks, on the old mountain which overlooks thy fertile plain, I was born. Little did I think, whilst playing some childish game within sound of the murmur of thy

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ripple, that I should some day cross over thy stream suspended to this light aërial globe! Thy peaceful waters flow towards the Rhine and the North Sea, into which they fall, and are lost for ever. Thus is it with our own brief existence, flowing towards the regions of cold and mystery, to vanish some day in that unknown ocean into which we must all descend. . . . .

"See! *mon ami*, how beautiful this is! Do not dream of days gone by. Are not those the lights of Namur, some six or eight leagues distant? And see, there is Huy, and beyond it again Liége! Here we are right over Belgium, and we may cross a corner of Holland, perhaps, before we enter Prussia!"

These observations from my worthy pilot bring back my thoughts to our present situation. We are over the district of the Sambre and the Meuse, which recalls to our mind the military aëronauts who were attached to the armies of the French Republic, and who observed the disposition of the enemy's camp by means of balloons. Perhaps the gaining of the battle of Fleurus was due to them.

Since that time balloons have been little used in warfare. In 1859 M. Eugène Godard was called to Solferino, and the balloon which was to have served on this occasion carried us up on our first aërial excursion.

The Belgian towns, lit up by gaslight and the flames issuing from the smoky summits of the blast furnaces, present to us silent aërial navigators the most singular spectacle. The deep sound of the Meuse, as it flows along its course, is accompanied by the sharper noises from the workshops, whose mysterious flames and dark smoke rise in the distance around us.

The night passes by almost before we are aware of it. As early as twelve o'clock, although we are yet far from the summer solstice, the pale twilight was distinctly visible in the north. The light of the moon is diffused through the sky; the clouds are not opaque enough to interrupt its rays.

Green and Monck Mason, on their long night journey from London to Germany, accomplished on the 7th November, 1836, passed over this spot also, over Liége and the Belgian blast furnaces. They tell us that after midnight the lights below were extinguished; that there was no moon in the sky, though the stars shone brilliantly; nevertheless absolute darkness reigned around them. They compare the darkness to a "mass of black marble, which yielded on our approach, allowing us to enter still more deeply into its cold dark sides."

I must confess that in the three night voyages which I have made —in one of which the sky was overcast, and there was no moon—I

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never experienced any such sensation, but I agree with these travellers as regards the severe character, the silence and the solitude of such a journey prosecuted at some five or six thousand feet above the surface of the earth.

During a period of profound silence and relative darkness we heard a remarkable noise above us, as if the silk of the balloon had cracked and the gas were flowing rapidly from the opening. The real cause of this was soon discovered: the network creaked upon the silken envelope from the effects of damp, and the three little balloons [1] were rolling along the equator of the larger one, their friction against the envelope causing a slight noise, which, in the profound silence, appeared more intense to us than it really was.

After midnight time appears to fly rapidly. At 1h. 30m. the twilight is tolerably luminous, although the air is veiled by mists. We lighten the balloon by throwing out a few pounds of ballast, and rise gradually and slowly to a height of 4,920 feet. We leave the three towns, whose lights we perceive one after the other to our left, and at 2h. 50m. we pass Liége on our left.

Whenever we sail above the clouds the moon shines forth with peculiar brilliancy. Venus glitters through the morning dawn, and the twilight is intense enough to produce shadows.

Above the light of dawn we have truly a fairy scene: clouds of every shade, which have accumulated in these higher regions, form the most wonderful of landscapes, not unlike the curious pictures drawn by the hand of Nature on certain descriptions of agates, and we would imagine that we had before us several antique towns situated among vast Alpine ranges, and somewhat vaguely distinguished through the mist, high above which extends the pure sky.

Although the air below is more or less veiled by light mists, we can distinguish the country, before three o'clock, as clearly as at mid-day. Our course follows the edge of some considerable forests situated on our right hand. These plains (are they plains?) have a very different aspect from those on French territory. In place of the regular patches of fields which lie upon the surface in parallel lines like the squares of a thin board, the country here is composed of fields of every size and form, like the various provinces on a coloured map; most of which are surrounded by hedges as they are in England.

For some time, already, we have been able to perceive the course of the Rhine, though we are still sixty miles distant from it. We leave

[1] This is the first time that the author mentions these three small balloons attached to the circle, a woodcut of which is given a few pages further on; and they are alluded to again in the sequel.—T. L. P.

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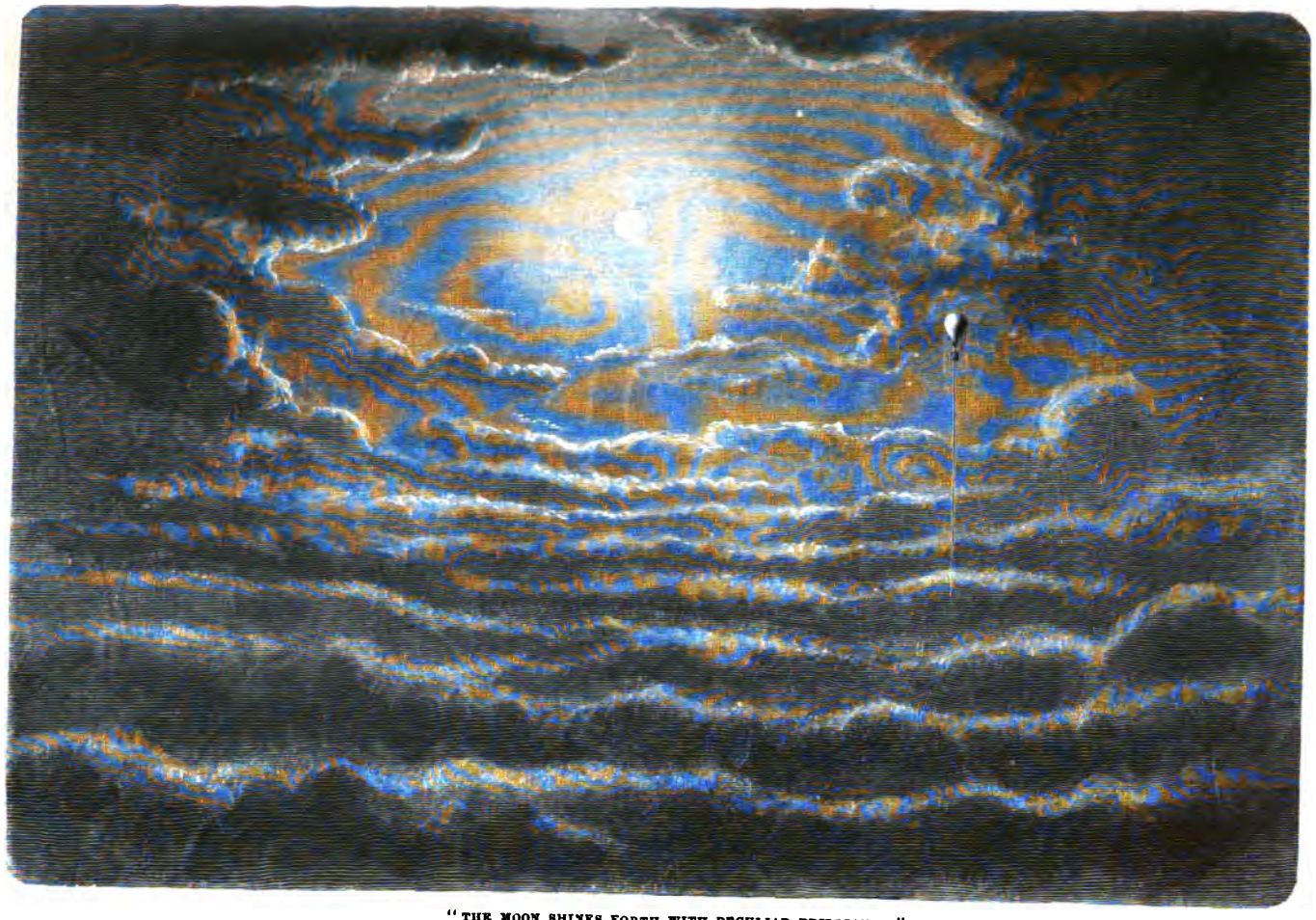

"THE MOON SHINES FORTH WITH PECULIAR BRILLIANCY."

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Spa on the right of our course. Until this voyage, that which was made from Paris to Spa in 1851 by M. Eugène Godard, accompanied by the Princess de Solms (Madame Rattazzi) and five other noble travellers, was the largest excursion ever achieved by my worthy pilot. In future this will rank third, as our journey to Angoulême was fifty miles longer, and the present one will be upwards of sixty miles in excess of it.

The last Belgian town which we pass is Verviers, and at 3h. 40m. we pass into Prussian territory by the little town of Eupen.

About 3h. 15m., whilst sailing along at a height of 5,906 feet, the hygrometer marking 93 and the thermometer being at 41° Fahr., we witness with much interest the *formation of clouds*, which develop themselves rapidly both above and below us. The country, which since day-dawn had exhibited an infinite variety of rich tints, is now gradually masked from view by the accumulation of fleecy cloud fragments. We have scarcely time to admire the vast variety of tone and colour, the villages, the woods, the roads, and the fields, before the formation of abundant white clouds cuts off the view on every side. At first they are quite diaphanous, but they suddenly become opaque and completely hide the lower regions from sight.

These clouds are formed and vanish again with astonishing rapidity, and we might almost ask what fairy wand orders them to appear so mysteriously over the surface of the country. From the hygrometrical observations taken this morning, I am of opinion that currents of cold air circulate through the atmosphere and condense into visible cloud the layers of damp air through which they pass. Then the slightest current of warm air causes the mist vesicles to disappear again.

The small clouds are, moreover, attracted mutually to one another; no sooner are they formed at various points than they approach each other and unite into one mass. We sailed for two hours above these clouds, which lay along a zone situated at a height of from 3,280 to 5,900 feet; some of them may, consequently, have been about 2,600 feet thick. Sometimes our balloon actually seemed to float along the surface of this cloud ocean, and the residence of man below was then completely eclipsed from our sight, and was, for the time, far from our thoughts also.

Our balloon has continued to rise, and we are now 6,560 feet high. And what are those golden fires which light up the eastern horizon as if the whole hemisphere beyond were in a state of conflagration? It is the approaching sunrise, which we shall presently have the privilege of witnessing in all its grandeur, for we are now 6,560 feet

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above the valley of the Rhine. Our Paris chronometer marks only half-past three, and the *Annuaire du Bureau des Longitudes* informs us that sunrise is at 4h. 14m. But then we are at Aix-la-Chapelle, 3° 44′ to the east of the meridian of Paris, and at an elevation of 6,560 feet, which will account for it all. On our right we can distinguish the province of Luxemburg to beyond Trèves, and on our left we can trace Holland to the shore of the North Sea.

The Rhine flows along with its silver ripple in the distance, like a serpent spread over the green surface of Germany, and whose flattened head reposes at the edge of the North Sea. All nature is silent, save from time to time the timid chirping of some little bird; when, suddenly, a vast golden streak of light breaks forth from the east and caresses the highest clouds of the atmosphere, clothing them in rosy and golden tints. The orb of day has just appeared, and its golden disc flies amid the purple clouds which have separated on its approach.

As the sun rose gradually from the other hemisphere our balloon also rose in space, and we were 7,546 feet above the earth when its glorious rays shot above the lower strata of clouds and penetrated between the lower cloud zone and the highest grey atmosphere, which was decorated only by a few white streaks of vapour.

At 3h. 54m. the sun appeared to us to rise a second time. Hidden, at this moment, behind some dense rows of cloud, we could easily imagine that its disc had not yet risen; when we saw it again upon the horizon, it had no longer a deep scarlet tint, but one of silvery white. It was the waters of the Rhine reflecting the dazzling image of the sun's disc towards us at this instant.

Before we have reached Aix-la-Chapelle we can see Cologne with the naked eye, or, rather, we can distinguish the cathedral as a dense black mass upon the silver background of the river's course. At 4h. 26m. we pass directly over the railway station of Düren (which is on the line from Aix to Cologne).

Whilst we were at an altitude of 7,870 feet and passing above a layer of clouds, the sound of church bells reached our ears; it was the first terrestrial noise we had heard since the music last night.

The sound of bells is very soft and sweet as heard from the skies, but we were not allowed to enjoy it long, for it was soon followed by the sound of cannon; and from minute to minute the voice of this gracious apparatus of civilization and progress growled among the clouds. It was the artillery of Mülheim preparing itself for the next war.

The ancient city of Cologne forms beneath us a regular semicircle

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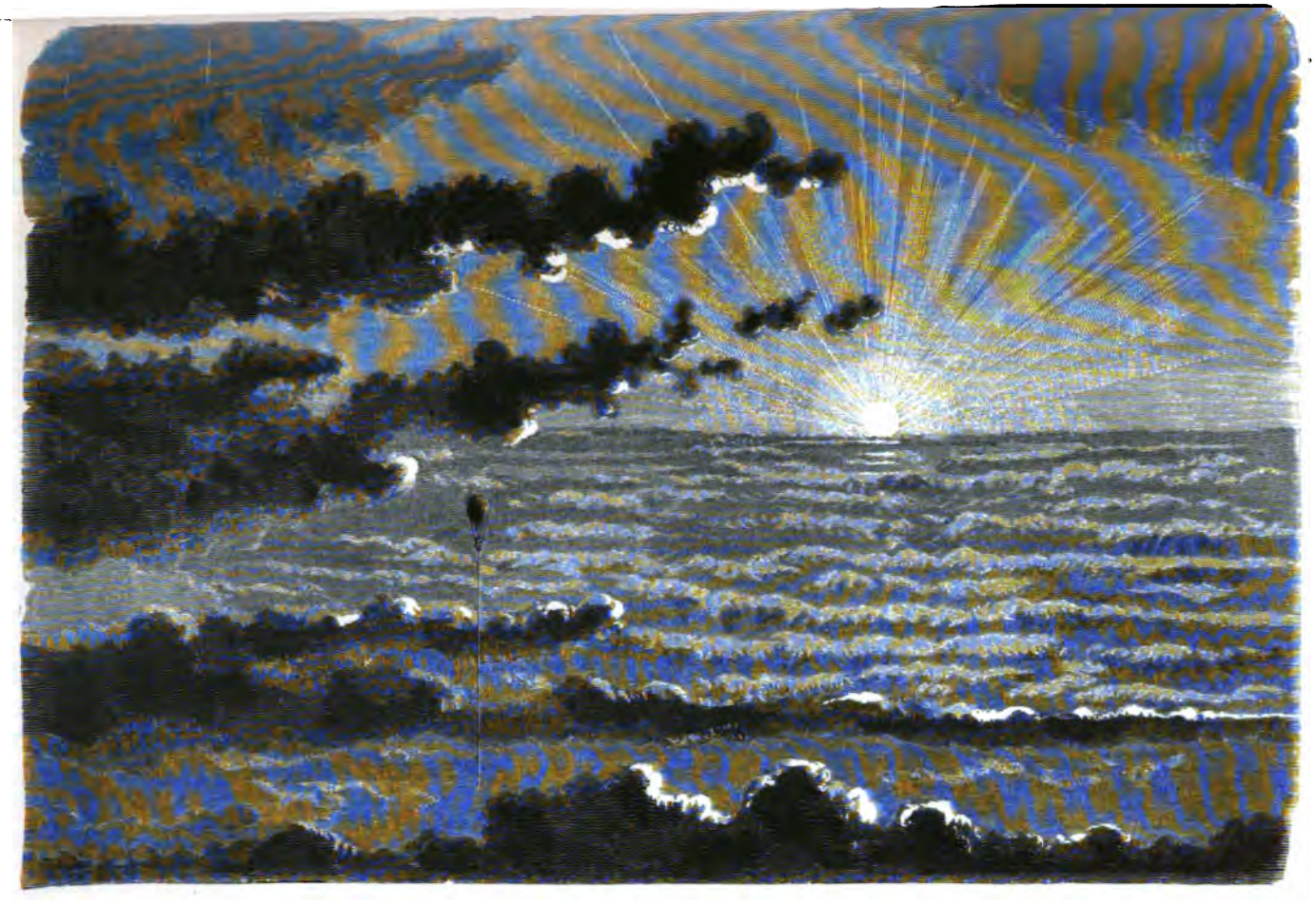

"THE ORB OF DAY HAS JUST APPEARED, AND ITS GOLDEN DISC RISES AMONG THE PURPLE CLOUDS."

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soldered to the left bank of the Rhine. Unless one examined it somewhat attentively, it might be taken for a moderate-sized snail sticking to the thin branch of a tree. We are sailing along tranquilly and magnificently at a height of 5,900 feet, admiring the rich landscape of the Rhine, the Siebengebirge and their picturesque valleys, the vales and hills of Westphalia, and the course of the river towards the grey landscape of Holland.

The moisture of the air had been gradually diminishing, and the hygrometer marked 62; the thermometer was at freezing-point. But the sun had at last penetrated the clouds, and shone brilliantly; it was the finest period of our long journey, and we were fully enjoying the magnificence of the spectacle before us; the balloon, instead of sinking, rose still higher under the influence of the drier atmosphere which now surrounded us. What man, in face of such a splendid spectacle and feeling perfectly secure in the midst of the azure vault, could ever dream of returning again to the earth's surface? Alas! there was a man who, by a kind of nostalgic desire to gain the ground, was at this moment anxiously inspecting the green plains of Prussia; and this man was precisely Eugène Godard!

When I saw his hand approach the valve-rope, I threatened as severely as I could to denounce him in the public journals. I begged him to let the wind carry us on to Berlin; I tried to convince him that his aëronautic reputation would benefit considerably thereby, that my meteorological observations were not completed, that the balloon was still good for a length of time, &c. All in vain.

My companion replied that a journey of more than 300 miles (by the road) was pretty well for one sitting; added that we had scarcely any ballast left for the aërostat, and no breakfast for ourselves; and finished his discourse by repeating that the wind always rises in the morning, that with our present resources we could not hold out for the whole day, should be forced to descend before mid-day, and should probably meet with some accident, as we had no ballast wherewith to counteract an unforeseen fall or the intense wind of the plains.

I could not do otherwise than accept his arguments, and bow before the greater aëronautical experience of my celebrated guide, who thereupon pulled the valve-rope as we were crossing the Rhine at half-past five o'clock.

The three little balloons attached to the circle of our aërostat caused us to descend in a spiral direction. The earth seemed to turn round under us, and we appeared to be precipitated in a cycloid from the higher regions of the air. The sun lit us up brilliantly when we

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were only 2,920 feet high. The landscape below became more defined, and the dark mountains raised their peaks higher in the air as we descended lower than their summits. As we made our descent upon German territory, we put up the French flag on one of the ropes of the balloon. As soon as we got near enough to the ground to distinguish the people, we saw a multitude of peasants, in curious costumes and with enormous pipes in their mouths, running through the fields to meet us. When the car alighted gently on the surface of the green sward, plenty of strong arms were there to hold us securely down. Our greatest difficulty was to prevent the men smoking when they approached the balloon. Our ears were soon overpowered by the cheers and guttural shouts of these worthy Germans.

We had descended in the neighbourhood of Solingen, near Dusseldorf, 4° 45′ east of Paris, and 51° 6′ north latitude, having accomplished 330 miles in twelve hours and a half. Our intention was to have left the balloon inflated until the evening, and then to continue our journey: after being towed to a convenient place by the bystanders, my first care was to secure the meteorological instruments, to load the car with heavy stones, and then to pour the gas of the little balloons into the larger one, to replace that which had been lost; but a violent storm arose in the evening, and obliged us to empty the balloon of all its gas—much to our regret.

THE SATELLITE BALLOONS

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ASCENT OF M. FLAMMARION FROM THE GARDEN OF THE CONSERVATOIRE.

CHAPTER X.

FROM THE CONSERVATOIRE DES ARTS ET MÉTIERS TO THE GARDENS OF BEAUGENCY.

We have now come, dear reader, to the last aërial voyage of this series—that which we made on the 15th April, 1868. It may have been remarked that the narrative of each journey differs both in its form and object from that of the others; and if, instead of ten chapters, I had been asked to write one hundred, the field of observation is so vast that I doubt not every succeeding account would have differed widely from that which preceded it. For a long time the impressions thus produced will be endowed with novelty, and will always present themselves to the mind under new and unexpected aspects. We who inhabit the earth's surface have scarcely any more perfect notion of Nature, of the grandeur and active work of the atmosphere, than the fish which swim at the bottom of the sea can have of the surface of the ocean, the currents, the tides, or the phenomena of heat and light which constantly occur in the higher regions of their ocean. The aërial ocean contributes largely to the life and beauty of the globe. We vegetate on its shoals and in its shallow waters, and remain ignorant of the grand spectacles afforded in its greater depths. The contrast between this state of ignorance and the richness of their higher regions is so great that I

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cannot understand how it is that man has not become domiciled above the clouds, in that pure and beautiful region where it never rains, where snow is never seen, and where the soft light breeze wafts our car along without making itself perceptible.

The aërial excursion which is the subject of this chapter is not so extensive as the last, and will not take us across the Rhine. But it has its special character. It is not always the longest journeys which are the best or the most instructive, and Nature often presents us suddenly with some new spectacle which we little expected.

I will observe once more, in commencing this account, that the presence of a professional aëronaut is exceedingly useful in an aërial excursion made for scientific purposes; the observer is too much occupied to attend to the balloon, and the management of the latter requires, as we have seen, a thoroughly experienced person, whose attention must be constantly riveted upon the ever-varying equilibrium of the aërostat as it proceeds on its course.

We rose from the garden of the Conservatoire, where sixty-four years previously Gay-Lussac and Biot made their memorable ascent. The instruments were all compared with standards before we started. It required five hours to inflate our balloon of 42,000 cubic feet capacity. At three o'clock M. Eugène Godard and myself took our seats in the car, and at 3h. 15m. we rose very rapidly and in a south-westerly direction.

Attached to the network at the equatorial line of the balloon might have been seen hanging a circular piece of tissue; it was a parachute about a yard wide only, which may be used to moderate the rapidity of an ascent or a descent, as proposed by Count Xavier Branicki, with whom our readers have made acquaintance in a previous excursion.

This parachute, which we here tried for the first time, caused the balloon to oscillate for some time, for we were obliged to rise rapidly on account of the wind. The weather was overcast since the morning, and slightly wet about noon, and at the moment we started there was no break in the clouds. At the first glance below we could not help feeling some surprise at the sight of the immense crowd which was stationed outside the garden around the Conservatoire. It seemed as if all Paris had come to witness this ascent, in spite of the care I had taken not to make any announcement of it beforehand.

One minute and fifty seconds after our departure we crossed over the Seine and the new Tribunal of Commerce, being then

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2,020 feet high; three minutes later we took as a guiding point my little observatory near the Pantheon, being then at a height of 2,220 feet. At 3h. 25m. we crossed the fortifications between the Porte d'Arcueil and the Sceaux railway, and at a height of 3,120 feet.

At this moment—and it is the first time I ever noticed it—the current changes its direction, and is now due south. At 3h. 34m. we shall pass to the east of Bourg-la-Reine, and later (at 3h. 53m.) shall leave Lonjumeau to the west.

The temperature decreases rapidly as we rise. The standard thermometer at the Conservatoire marked 59° Fahr. in the hall on the ground-floor; my thermometer marked also 59° in the garden before we started. At an elevation of 1,969 feet it had sunk to 46°·4, at 2,460 feet to 42°·8, at 2,838 feet it marks 41°, at 3,117 feet it is 39°·2, at 3,773 feet 37°·4, and at 4,265 feet it marks 35°·6.

I seek in vain for the lower level of the clouds; they are not spread out in a uniform layer, as I have sometimes noticed, but are disseminated here and there. When we arrived at a height of 3,937 feet, many were seen dispersed like immense light flakes of wool beneath us.

Our breath condensed in steam whilst we soared through a zone of air 3,770 feet high, where the hygrometer gave its maximum indication, and where the thermometer marked 37°·4. There were no clouds; but it was near the lower limits of the disseminated layers. Higher up again our breath did not condense in this manner. At 4,120 feet we are almost completely enveloped in clouds; the earth disappears gradually from sight; the general aspect of the country, the woods and lanes, are still visible; soon, however, the ground is hidden from sight, and at 4,642 feet we are at the higher level of the clouds. Their density is slight, and to-day I do not experience the singular effect produced upon me the first time I plunged into an immense layer of clouds, when I was astounded by the light which beamed into them, producing a joyous effect as we soared out of the lower regions and through immense masses of cloud.

But a marvellous spectacle awaited us. At a moment when we least expected to see anything remarkable, and whilst I was carefully noting down the indications of the hygrometer, we found ourselves near to the singularly undulated surface of the cloud-tops, and suddenly—at less than 100 feet from us perhaps, and opposite to the sun, which had just revealed itself—we see the lower

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portions of a balloon about the same size as our own, and suspended to it a car containing two travellers, whose forms are so familiar that we recognize them without any difficulty.

The minutest details are apparent, even the thinnest ropes and the cords and instruments suspended to them. I make a motion with the right arm,—my spectre moves his left. Godard flourishes the national flag, and the shadow of a flag is moved by the spectral hand in the air. All around the image of the car we see concentric circles of various colours: in the centre a yellowish white background, on which is depicted the form of the car; then comes a pale blue circle, around which is a yellow zone; then again a greyish red zone, and finally a light violet tint, forming the external circumference, and blending itself gradually into the grey tone of the clouds.

It is not the first time that this interesting spectacle has been witnessed. It is the first time it was ever seen from a balloon,[1] no doubt; but there is nothing very surprising in this, as balloon ascents have been so very rare (!) up to the present time. In mountainous regions several observers have noticed and measured these said luminous aureolæ. Certain popular treatises on meteorology have long since given representations of the phenomena in question, under the name of *Ulloa's Circles*. In these engravings we see a traveller (Ulloa himself) standing upon a mountain; at a certain distance from him we see his shadow represented vertically, and around his head we have first a luminous circle, then a series of rings of various colours. It was a phenomenon of this description which I had just witnessed from the balloon. But it was not exactly an Ulloa's circle either, and I heard it described recently in a popular lecture-room, in a very gracious manner, as *Flammarion's Circle*. But it is needless to incorporate another surname into treatises on Physics (unless it be for the purpose of showing that Ulloa's phenomenon is somewhat variable in its aspect), since we have nowadays grouped all these effects under the generic name of *anthelia*.

The word *anthelia* indicates by its derivation that the phenomena in question appear in that region of the sky which is opposite to the sun. They were seen by La Condamine, Bouguer, and Ulloa in the Cordilleras. The shadow of the observer is figured upon the surface of a mist or vapour in proximity to the spot where he

[1] I always saw the image of the balloon, the car, and ourselves, surrounded with several luminous concentric circles, on the clouds, on passing above them in bright sunshine.—Ed.

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stands; a light aureola surrounds the head of the figure. "What surprised us most," says Bouguer, "was to find the head of the figure surrounded by an aureola formed of three or four concentric circles of very vivid tints, similar to those of the rainbow, the red being outside. It was a kind of glory, and each spectator contemplated with selfish delight that which surrounded his own head, without noticing those which appeared also about the heads of his neighbours."

Ulloa relates, in his turn, that each of them saw his shadow in the centre of the three rainbow circles, surrounded by a fourth circle of one colour. "The most external colour of each bow," says he, "was scarlet or red; the tint next to it orange, the third yellow, the fourth straw-colour, and the last green. All these segments of circles were perpendicular to the line of the horizon; they moved with the motion of the person whose image they surrounded like a glory. At the commencement of the phenomenon the form of the arcs was oval, but towards the end of it they were perfectly circular."

The same apparition was formerly noticed by Scoresby in the polar regions. According to his description, it is seen whenever there are sunshine and fog at the same time. In the polar regions when a layer of light mist rises on the sea, an observer placed on the mast-head sees one or more circles upon the fog. These rings are concentric, and their common centre is situated upon the straight line which joins the eye of the observer and the fog, on the side opposite to the sun. The number of rings varies from one to five; they are most numerous and brilliant when the sunshine is very bright and the mist thick and low. On the 23d July, 1821, Scoresby saw four concentric circles around the shadow of his head. The colours of the first and second were very vivid, those of the third were visible only at intervals, being very faint, and the fourth was formed merely by a slight tint of green.

The German meteorologist Kämtz has often witnessed the same phenomenon in the Alps. Whenever the shadow of his head fell upon a cloud, it was seen surrounded by a luminous aureola.

To what peculiar action of light must we attribute these effects? Bouguer declares that they result from the passage of light through crystalline particles of ice; such is also the opinion of De Saussure and Scoresby.

The observations made from the balloon as described above prove clearly that this cannot be the case. On the heights of mountains we cannot assure ourselves directly of the fact by rising into the

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cloud which shows the phenomenon; but the balloon allows us to pass into and through the clouds, and to soar into the very spot where the optical effect takes place, so that we can easily examine the state of the cloud. At the moment on which we saw the phenomenon we had risen to a height of 4,593 feet, and were at the higher level of the clouds (this surface was far from uniform, being excessively undulated and broken). The thermometer marked 35°·6. The hygrometer had indicated its maximum (77) 820 feet lower down, in the lower portion of the cloud zone; it had then risen to 73. The aqueous vapour that formed the cloud in which the phenomenon occurred was quite devoid of any particle of ice. I therefore adopt the opinion of Professor Kämtz, that anthelia are caused by the action of the vesicles of mist upon light. The phenomenon may therefore be referred entirely to the diffraction of light as asserted long ago by Fraunhöfer, and confirmed by some observations of Kämtz, in which he noticed a single corona or small halo when the cloud was between him and the sun, and an anthelion when the same cloud had got opposite to the sun.

This phenomenon does not differ essentially from that which we noticed in the preceding narratives when speaking of the *luminous shadow of the balloon;* for as our aërostat rose higher above the clouds, we saw the outline of the balloon get smaller and the coloured aureola increase in size, so that, instead of merely surrounding the image of the car, it soon enveloped that of the entire balloon. The colours then got fainter and disappeared, leaving merely a luminous shadow with a dark nucleus as a centre, which shadow travelled with us along the clouds. We have already seen that this luminosity is owing to the reflection of light from the little vesicles of water or dew-drops.

The sun is very hot, and dilates the gas of the balloon, thereby increasing our ascensional power. Above us we have the pure blue sky, and the shadow of the balloon is much smaller and further from us; it shows itself more distinctly when it happens to fall upon thick clouds; the rainbow colours surround it completely. A vast incommensurable ocean now lies beneath us, broken up here and there into enormous fleecy blocks, which curve and heave themselves into various forms and positions with extraordinary rapidity. When we skim over the upper surface of these heaps of cloud, we sometimes penetrate into enormous white mountains of vapour, and cannot help feeling surprise at the fact of their offering no resistance to our progress.

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It is truly a magnificent spectacle that we have before us when suspended as it were in a vast vacuum above an uninhabited ocean formed of immense undulating cloud heaps, the hills and valleys of which continue to the furthest points of the celestial horizon. The earth is completely hidden from sight, and men live down below enveloped in dreary fog or relative darkness without dreaming of the splendid sunshine which reigns here above.

At 4h. 10m. we are sailing along at an altitude of 5,250 feet, and a break in the clouds below allows us to get a glimpse of some town surrounded by large gardens and plantations. It must be Arpajon. But the gap closes; the clouds travel very fast in a contrary direction to our course; this appearance is no doubt due to the fact that we are travelling much faster than they are. Sometimes we feel rather a strong breeze, which, as everyone knows, is a rare occurrence in a balloon.

We hear dogs bark, and the roll of a drum. We have risen still higher, and are now at a height of 7,550 feet.

The hygrometrical observations have been fertile in important data concerning the distribution of moisture with the height. At the surface of the earth the moisture is marked on the hygrometer as 73. It has been as follows for the various altitudes named:—

Hygrometer.	Altitude in feet.
72	1,969
74	2,546
75	2,953
76	3,412
(Maximum) 77	3,773
76	4,036
75	4,528
73	4,593
70	4,757
67	4,889
64	5,003
61	5,128
57	5,210
55	5,249
48	6,562
30	9,843

Though the sun is hot to the face, the temperature of the air has constantly decreased. At the altitude of 9,840 feet our thermometer was at 19°·4 Fahr. At that of 13,620 feet, which was our greatest altitude, we had 10°·4, although the heat was almost intolerable upon our heads.

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It may be difficult to describe the novel impression produced upon the mind of the observer in these elevated and desert regions; but when a thick layer of cloud separates us completely from the earth, we feel severed, as it were, from the sphere of life. Although the spectacle which presents itself is fine beyond description,—though these vast expanses cannot fail to produce a gloriously imposing effect rather than one of sadness,—yet the vital functions are no longer accomplished with regularity; a dryness arises in the throat, the lungs are more or less affected, and the presence of blood upon the lips produces a disagreeable effect,[1] which is constantly mixed up with the contemplation of these grand scenes and the investigation of the curious phenomena around.

When we had arrived at our greatest height, some clouds which had not yet taken the form of cirri, but were disseminated across the blue sky as "mares' tails," caused the gas of the balloon to condense. The sun's rays had already caused a considerable quantity of gas to escape by dilatation; so that when this condensation occurred, we sank very rapidly to about one-half our elevation; in a few minutes we descended no less than 6,560 feet. However, we did not reach the lower level of the clouds, thanks to our ballast, and we continued our route at an altitude of 4,920 feet.

The little town of Etampes passed under us almost as an invisible object, whilst we glided at a height of from 10,000 to 13,000 feet above some transparent clouds.

At 4h. 55m. the clouds became less dense, and we saw beneath us Angerville. We had just crossed the Orleans railway, to the left of which we sailed for a whole hour. A train from Paris followed us for a long time, but we progressed more rapidly than it, and with infinitely less noise!

We pass Arthenay on our right at half-past five, and Chevilly at 5h. 43m.; we cross the forest of Orleans and the railway, and bear now more and more towards the west; we leave Orleans to the left, and come upon the Loire at Mareau, following its course for some time.

The sound that was most frequently heard during this excursion was that of the drum. Experiments which we made upon the echo, show that sound returned to us in eight seconds when we were between 4,436 and 4,518 feet high; and in a second and a half when at a height of 837 feet over the river Loire.

We followed the course of the Loire for a long time, and at a comparatively short distance from its surface. As the condensation

[1] I never experienced any of these effects till I had long passed the heights reached by M. Flammarion, and at no elevation was there the presence of blood.—Ed.

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of the gas continued, and our ballast was well-nigh exhausted, it would have been imprudent to continue our journey and await the approach of night. The trace of our route upon the map told us that we might arrive at Chambord in about half an hour, and get to the south of Tours by half-past eight o'clock. Supposing us to have gone further, we should have reached Loudun at ten, Napoléon-Vendée about midnight, and then on to the ocean, which would not have been very agreeable on so cold a night, and without the light of the moon. We cast our anchor at 6h. 57m. at Beaugency, having sailed ninety miles through the air in three hours and forty-two minutes. When at the height of 13,000 feet, we progressed at the rate of thirty-four miles an hour.

Beaugency is the town in which the physicist Charles, member of the Academy of Sciences, who was the first to make an ascent in a balloon filled with pure hydrogen gas, was born; and we had the good fortune to make our descent precisely upon a piece of ground belonging to a relative of the late distinguished aëronaut. The farmer who rented the land wished to make us pay something for the damage caused to the crops, &c., by the crowd of people who rushed in to witness our descent, but the proprietor, reminded by our visit of the excursions of his celebrated relative, would not hear of it.

In concluding the account of this journey, I may state that among the instruments experimented with, was a special aneroid barometer, which we compared carefully in its indications with an ordinary mercurial barometer, and have come to the conclusion that the former instrument may be used with perfect confidence. The instrument in question was specially prepared for this ascent by M. Richard. It is certainly much more convenient than the mercurial barometer, and delicate enough to indicate distinctly a rise or fall of two yards.

It was very agreeable to me to conclude this series of aërial travels with so vivid a reminiscence of the first philosopher who made an ascent by means of hydrogen gas: what a period of enthusiasm it was!

We have not made much progress, it is true, since then with respect to the guidance of balloons, but the young science of meteorology has already gained much, and will in time be placed in possession of the laws which govern the currents of the atmosphere.

The first sailors who navigated the ocean were obliged to discover the laws and periods of the various winds, so that they might choose the proper seasons for their voyages. The same lot awaits our

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aërial navigators, and the conquest of the atmospheric ocean will not, we hope, be delayed another century.

We may devote the conclusion of this chapter to a rapid enumeration of the results of my scientific observations, which have only been casually alluded to in the foregoing narrative.

First with regard to the distribution of moisture in the atmosphere according to the altitude. It results from ten series of observations specially made for this purpose, and taken at some 500 different positions—1. That the moisture of the air increases from the surface of the ground to a certain height; 2. That it reaches its maximum in this zone; and 3. That above this zone it decreases constantly as we rise into the higher regions. This zone, which I will call the *zone of maximum damp*, varies in height according to the time of the day, the period of the year, and the state of the sky. In rare circumstances (especially at dawn) it is situated near the surface of the ground. This general distribution of moisture appears to be constant, whether the sky be clouded or fine, and whether the observations are made at night or in the daytime.

Somewhat connected with this is the *increase* of the diathermous property of the air as we reach great heights and as damp *decreases*. At all altitudes greater than 6,500 feet or thereabouts, it is impossible not to be struck with the intensity of the solar rays; a difference of 25° to 34° Fahr. has been noted between the indication of the thermometer outside the car and that in the shade of the interior of the car.

With regard to the circulation of air currents, it is curious to note that the traces of my different aërial voyages are all represented by lines which have a tendency to curve in one and the same general direction. Thus, on the 23d June, 1867, the balloon started with a north wind, directly towards the south, but it soon veered slightly towards the west, becoming gradually south-south-west, and after a while due south-west when we descended. A similar result was observed in every excursion, and the fact led me to believe that above the soil of France the currents of the atmosphere are constantly deviated circularly, and in a south—west—north—east—south direction. Is this phenomenon to be attributed to the law of gyration of winds recognized by Dove, or the solar action and diurnal variation in the temperature of the atmosphere as FitzRoy supposes? Or is the fact due, as Hadley thought and as M. Bourgeois has recently affirmed, to the variable velocity of rotation of the earth's surface around the central axis of the globe in different parallels of latitude? Lastly, have we in this circumstance the

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general current of the trade-winds described by Maury? I cannot at this moment decide upon the exact nature of the deviation I have described. The velocity of the currents in which we travelled generally increased somewhat the longer we remained in them. They are, moreover, variable with the altitude. It appears to me also that two or more currents flowing in different directions are very rarely met with as we rise in the air; and when two layers of cloud appear to travel in opposite directions, the effect is generally caused by the motion of one layer being more rapid than the other when the latter appears to be moving in a contrary direction.

I have made 550 aërostatic observations upon the decrease of temperature with the altitude, and it results from them that this decrease is more rapid when the sky is fine; slower when it is overcast. With a clear sky the *mean* decrease was 1° Fahr. for 345 feet; in a cloudy sky the *mean* decrease was 1° Fahr. for every 354 feet.

The temperature of the clouds is higher than that of the air above and below them.

The decrease of temperature is more rapid in regions near to the surface, and becomes less rapid as we rise higher. It is more rapid in the evening than in the morning, and on hot days than on cold days. Sometimes we meet with regions which are hotter or colder than the mean temperature corresponding to the observed altitude; they appear due to warm or cold currents flowing through the air.

I have found it convenient to class clouds into two varieties only; namely, *cumulo-stratus*, which when they lie upon the ground are like enormous masses of grey steam, or when seen at the zenith like large bales of cotton, and which appear to touch each other when seen in perspective near the horizon. The other description is the *cirrus*, little white clouds appearing in the higher regions, taking various tints in the evening, sometimes mottled, and often floating in long narrow strips. I leave aside the stratus, which does not exist in the daytime, and whose form appears due to an effect of perspective; and the nimbus, which merely indicates the shape taken by a cloud when it resolves itself into rain.

Alluding only to the two special classes of cloud, the former (cumulo-stratus) are usually situated between the altitudes of 3,250 feet and 4,900 feet from the earth's surface. But they are occasionally met with beneath and above these altitudes. The second class (cirrus) are never lower than five times the mean height of the other description.

The maximum of relative moisture is found underneath the lower

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level of the clouds. The temperature increases, on the contrary, as we rise into the body of the cloud itself.

I have already alluded to some experiments on sound, made during our excursions. I find that the intensity of various sounds emitted at the surface of the earth is carried up to very great heights in the atmosphere. The whistle of a locomotive rises to near 10,000 feet, the noise of a railway train to 8,200 feet, the barking of a dog to 5,900 feet; the report of a musket is heard to about the same height; the shouting of men and women can be heard sometimes as high as 5,000 feet, and at this altitude the crowing of a cock and the sound of a church bell are audible. At a height of 4,550 feet the roll of a drum and the music of an orchestra are distinctly heard. At 3,255 feet in altitude, a man's voice may make itself heard; the rolling of a cart on the pavement can be distinguished somewhat higher; and in the stillness of the night the course of a river, or even that of a small stream, produces at this elevation almost the effect of a high water-fall. At a height of 3,000 feet the croaking of frogs in a morass is heard in all its intensity, and even the sharp note of the mole-cricket is distinguished easily at an altitude of 2,500 feet.

It is very different, however, as regards sounds which travel downwards from the balloon to the earth. Whilst we can hear distinctly the voice of a man shouting 1,600 feet below us, he cannot distinguish what we say until we sink to within 330 feet of him.

Clouds form no obstacle to the transmission of sound, as I have before observed.

As to the velocity of sound, I could only estimate it roughly by experiments in the echo, by means of a good chronometer. The mean velocity thus obtained, deduced from the double trajectory of the sound from the balloon to the earth and back again, falls between 1,083 and 1,875 feet per second.

The scintillation of the stars is much less in the higher regions of the air than at the surface of the ground.

At elevations greater than 10,000 feet, the sky directly above us appears dark and impenetrable. It has a greyish blue tint around the zenith, an azure blue in the zone between 40° and 50°, and pale whitish blue nearer to the horizon.

I have often noticed the apparent effect of the moon upon the clouds. It suffices to pass two hours in a balloon about the time of full moon, to perceive that certain light clouds are resolved and disappear as the moon rises higher above the horizon. Is it a simple coincidence, or has the moon a direct effect upon them?

Such is a very brief sketch of the principal observations, scarcely

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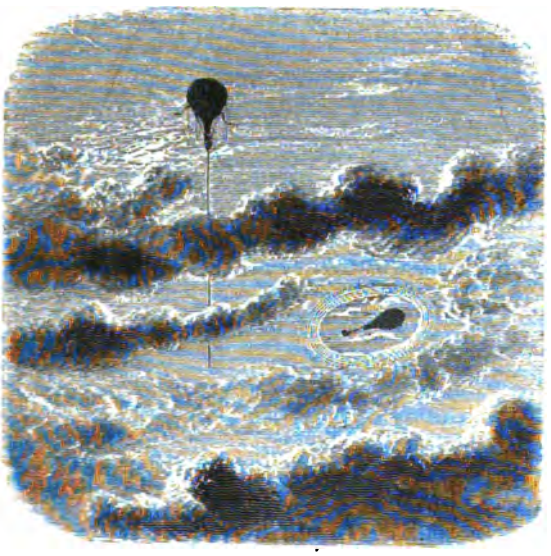
alluded to in previous chapters, made during my ten aërial travels. I have a few others which have not yet been sufficiently discussed to be presented here. I trust that those I have already given above may prove of some use to the science of meteorology. When the conquest of the air shall have been achieved, universal fraternity will be established upon the earth, everlasting peace will descend to us from heaven, and the last links which divide men and nations will be severed.



OPTICAL PHENOMENON OBSERVED BY M. FLAMMARION.

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PART III.

AËRIAL TRAVELS

OF

MESSRS. DE FONVIELLE AND TISSANDIER.

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THE "GIANT" BALLOON AND THE "IMPERIAL" BALLOON.

CHAPTER I.

THE LAST VOYAGES OF THE "GIANT."

(W. DE FONVIELLE.)

My friend Nadar begins his memoirs of the *Giant* with two necrological notices, one on the courageous Pilâtre de Rozier, and the other on the distinguished Dupuis-Delcourt. In spite of myself, I shall imitate him here, and this account of my first balloon ascents will commence in a similar manner, for the glorious Hanoverian balloon, the gigantic *Giant*, is dead! After having served in the excursions of which I shall presently relate the painful history, it was determined to transform this glorious son of the air into a captive balloon . . . but he would not allow himself to be confined to the air of the Cremorne Gardens! The three ascents of which I am about to speak may be considered as the three last gasps of the late *Giant*.

I cannot say how long ago the desire of rising into the air developed itself in my breast, but I was always one of those who envied swallows their wings; and whenever I happened to see up above the form of a balloon that had just escaped from some hippodrome or other, I always felt my heart beat—partly from pleasure and partly from fear of seeing the aërial navigators come to grief, for I was then ignorant of the ease with which such ascents can be made, and, all things considered, with what safety they can be accomplished.

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The means of guiding balloons also occupied my thoughts not a little, at a period when I did not understand the mechanism of a common steam-engine, but those thoughts ceased to trouble me when I became better acquainted with the car of an aërostat. I am not different from other people in this respect, and I firmly believe that the more a man becomes an aëronaut, the less he will torture the brains of worthy mechanics. Go up into the atmosphere, make yourself practically acquainted with it at various times and seasons, and you will become convinced, like myself, that we scarcely know, even yet, all the resources of a balloon! Before we discard the apparatus altogether, it is at least prudent and wise to ascertain what can be done with it!

Some twenty years ago I sketched out the project of a captive balloon with the view of initiating the public in these matters, a project which was afterwards carried out by M. Giffard, and in which I should undoubtedly have failed. But the *Coup d'état* happening about this time, I was promenaded from prison to prison until my aërostatic dreams vanished forcibly. This state of captivity produced in me, nevertheless, a passion for aërial adventure: I saw the clouds through the bars of the cage, I admired their ever-varying forms and tints, their rapid metamorphoses and curious movements. At night I saw the stars, but their distant light did not speak so eloquently to my soul as the clouds of my native country, rolling along like huge mountains of gold and silver upon the azure background of the pure sky.

I was formerly a pupil at the Collége Ste. Barbe, together with my two brothers, one of whom afterwards had M. Barral as assistant, at a period when the latter was Professor of Chemistry, and just about to make his memorable balloon ascents. When I returned to Paris after numerous peregrinations, M. Barral had founded a journal called the *Presse Scientifique*, on which I eagerly accepted a position. Whenever the opportunity occurred I never failed to ask my worthy editor-in-chief for some details of his aërial excursions, and listened with great attention to all his lectures, until, in fact, I believe I knew by heart all that could be said upon aërostatics in spite of the vastness of the subject.

I was bold enough to publish in the above-mentioned journal a few articles on aërial navigation, and I solicited rich amateurs of extraordinary adventures to come forward with the francs necessary to enable me to repeat the experiment which Ruggieri had made upon a sheep. I declared that I was ready to be shot up in a sky-rocket, provided that its projectile power were carefully calculated, and that

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W. DE FONVIELLE.

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UNIV. OF WICH.

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it were provided with a parachute. But it was all in vain; no capitalist presented himself.

The idea of making the experiment was suggested to me by some performances given at Algiers by the Brothers Braguet, on the Mustapha plain. These bold aëronauts abandoned themselves to the caprice of a small fire-balloon, inflated by hot air from burning straw. They rose at first with very great rapidity, which soon decreased, however; and when they had risen to a height of about 500 yards, they descended slowly about half a mile from their starting-point. Their performance lasted, at longest, not more than five or six minutes. Now, it appeared to me that the ascensional force of a sky-rocket might be regulated in such a manner as to permit an ascent of short duration, so that it could be employed, for instance, to get a peep into an enemy's camp in time of war. Rozier's sheep was not injured in making such an ascent—why should an aëronaut perish in a like experiment?

The ascents accomplished by the Brothers Braguet in Algiers met with a very mediocre success, in spite of my articles on the subject in the newspaper *Algérie Nouvelle*. The Europeans witnessed the spectacle with curiosity and pleasure, but the native Mussulmans did not appear to take the slightest interest in it. I remember, among others, a group of Arab chiefs, who had come to Algiers for the races, and got a sight of the balloon ascents gratis. None of them paid the slightest attention to the performance, and the only individual of the party who seemed at all interested in what was going on overhead was a large lion attached to the suite of one of these Koubars!

This is not the first time that ignorant and fanatic people have been noted as manifesting complete indifference to balloon ascents. After the taking of Cairo, when General Buonaparte wished to produce an effect upon the inhabitants, he not only made them a speech, but supplemented it with the ascent of a fire-balloon. The attempt was a complete failure, for the French alone looked up to the clouds to see what became of the balloon.

But I must return to the *Presse Scientifique*, from which I have digressed somewhat.

An inventor having suggested the notion of establishing a direct aërial communication by means of balloons between Paris and St. Cloud, I took upon myself to make known the difficulties, or rather the impossibilities, of such an attempt. How necessary it is to separate dreams and reality when the subject of aërial navigation is on the *tapis!* The world of the imagination borders so intimately upon the

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other, that common sense must be constantly on the alert, unless we wish to travel with Cyrano de Bergerac, Edgar Poe, and Jules Verne.

A captive balloon no longer pertains to the atmosphere, neither does it belong entirely to the earth. It is forced, if I may so speak, to serve two masters at the same time. It is at the mercy of the winds, and its anchorage to the soil is no protection to it. By bringing all the resources of art to bear upon its car, by covering the whole affair with an infinite amount of ropes, pulleys, &c., we cannot ensure its stability, nor answer a moment for its safety.

Finally, I protested firmly against the flying machines imagined by Landelle and Nadar.

Twice I contemplated the pleasure of making an ascent in the *Giant*, the first from Meaux, and the second from Hanover; but I only succeeded in getting a ticket to witness the performance. It was only five or six years later that I had the pleasure of seeing an ascent of the *Giant* announced to take place at the time of the Exposition Universelle, on the 23rd June, 1867.

This was the first balloon ascent which had taken place at Paris since the Hanoverian campaign, and an immense crowd came to witness it. Thousands of spectators pressed round the enclosure which contained the colossal balloon and its most illustrious captain, M. Nadar; the tickets of admission had been issued at prices varying from one franc to twenty francs, and the spectators were arranged accordingly, in concentric bands upon the esplanade of the Invalides, It was an unfortunate choice of position, full of sad souvenirs! It recalled the misfortunes of the *Globe* of Lennox, the *Eagle* of Godard, and of the *Flying Fish* of M. Delamarne. But the Champ de Mars was occupied—the Exhibition building stood upon it.

A large pipe had been placed in a ditch dug for the occasion, and conducted the gas to the centre of the esplanade. In order to occupy the attention of the spectators whilst the great balloon was being inflated, bombs, crackers, and small balloons of one cubic yard capacity were sent up into the air and produced a wonderful effect. These preliminary operations might have served to determine the direction of the wind at various heights, but they were only looked upon as a means of diverting the attention of the public from the large balloon in course of inflation; for they had to wait several hours. It was nearly four o'clock, in fact, before the network was joined to the car and the latter loaded with ballast. The car being attached to the hoop, and the last preparation for departure having been made, the travellers took their seats one by one, and, to my great joy, I find myself among them. There were M. Nadar, the illustrious captain;

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M. Simonin, a well-known mining engineer and a great traveller; M. Sourel, one of the astronomers of the Imperial Observatory, who was then occupied with a work on "The Bottom of the Ocean" (extremes meet in the atmosphere!); and some others.

Here we are, all of us in the car; but one more operation is yet requisite. We must put out a sufficient number of bags of ballast to give the balloon sufficient ascensional force. We soon find that we shall be obliged to depart without any ballast at all, unless we take care what we are about. One of the travellers must get out, we are too numerous. Upon whom will the eye of the ferocious captain happen to fall? Though protected by the presence of my chief editor in the car, I cannot help fearing that my aëronautic *debut* is now threatened. Luckily, I notice in the car an enormous copper case, like a huge chimney-pot, containing certain scientific instruments, constructed with the view of collecting air at the temperature of 32° Fahr. Now, although the *Giant* can carry up a weight of some 10,000 lbs., everything included, it is tempting the gods of the air to carry up such ponderous instruments as these. If we wish the science of the atmosphere to make rapid progress, our experimenters must not content themselves with sending up this heavy copper apparatus: they must come and make the necessary operations themselves.

The efforts of several hundred soldiers, who find it as much as they can do to hold the monster balloon, add to the interest of the scene. The dilettanti around are amused when these human beings lose their footing and remain suspended for a moment in the air, like bunches of grapes. We have not a single tool,—nothing that might facilitate the preparations,—and yet we are within a pistol-shot of the Universal Exhibition, where the marvels of modern machinery abound! Our aërostat is nevertheless completely in the savage state, as if it were on the banks of the Niger! After all these interruptions and oscillations, the peculiarly unpleasant effects of which I cannot possibly describe, the object before us is finally achieved, and I am the last to notice it. In fact, whilst I imagined we were still awaiting the termination of our struggle on the ground, here we are in the middle of the clouds!

Something similar, I conceive, must be experienced by each of us when we pass through those terrible doors of which Goethe speaks—when we pass from life to death. So rapid . . . . and yet so far . . . . nothing but a dream . . . . it seems like another life that is just beginning for us. There is the earth going away, and here are the clouds advancing upon us. . . . . Where are we? I have

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scarcely time to ask this question, when a thick cloud envelopes us entirely.

But in a little time the clouds disperse, and in one glance we embrace the spectators on the esplanade, and those still more numerous on the outside. The neighbouring streets appear paved with human heads. The grounds of the Exhibition and the parks are filled by a compact crowd of people. Sympathetic shouts reach us from all sides, and assure us that balloons are still popular. We are travelling along with the rapidity of the arrow from the bow, when suddenly I feel something strike my shoulders: it is like an electric shock. Is the balloon done for? What, already! . . . .

"It's the poultice," says some one, with an encouraging voice; but I had no idea what the said poultice could be; it certainly was not quite so soft as soaked bread or linseed meal. This is what had happened:—A certain quantity of sand had got into the interior of the balloon before it was inflated; it was mostly carried in by the shoes of those persons who went into the envelope to inspect it and repair any holes that might exist in it and allow the gas to escape. This sand had got agglomerated into a single mass, which in its fall had chosen me among the group of travellers in the car, and suddenly interrupted the flight of my imagination, which would doubtless have carried me into a region of fog far more dense than that in which we are now floating along.

The white clouds into which we have risen hide the ground from sight. We still hear the uproar that accompanied our departure, and already we must descend. It appears that the price paid for the admission tickets imposed upon the aëronauts the obligation of coming down before the night came on. Scarcely have we had time to admire the scene around the glorious sunset, than the valve-rope is pulled, and the famous poultice—a species of cement formed of suet and linseed, which covers the hinges of the valve—is broken away and the gas let out. The balloon soon sinks with increasing velocity. Adieu to my dreams of a journey into Spain!

In the first voyage made by the *Giant*, the rapid descent was attributed to the weight of the valve-rope, which kept the two edges of the valve slightly asunder and allowed issue to the gas. This time no such excuse could be made; and it was the hand that pulled the rope that was to blame. Our ascent, then, was only a pretext to descend again! If certain learned men are to blame for the indifference they manifest to aëronauts, what must be said of the balloon speculators who give such orders as these, and of the aëronauts who execute them?

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But I have no right to complain, as aërial hospitality had been offered to me; nevertheless, I boil over with indignation. I get a glimpse of the Bièvre whilst dreaming of the Danube; probably we shall fall on the banks of the former. As it happens, the valve-rope has been pulled so vigorously and so often that we must do something to prevent our legs being broken, so rapid is the descent. Without waiting for orders I begin to throw out ballast. The first thing that offers itself is a large packet consisting of some hundreds of copies of the printed prospectus of a new journal, a Government organ, whose editor is anxious that we should distribute his advertisement to the whole globe by the aid of the winds. Aquilon and Boreas are forthwith charged with the commission of announcing to the French Empire that one more defender of the Government has arisen.

Choisy-le-Roi becomes our Pillars of Hercules, the limit of our aërial world, for we shall not pass over Montlhéry, which we now see on the horizon. The anchor is thrown out and catches in the branches of an apple-tree. A large branch of the latter is torn off, and renders our progress somewhat slower; the open valve continues to give forth volumes of gas. . . . At last our motion ceases, and now the inside of the car will soon be shown to the public.

Some countrymen run up with an eagerness to help us which is beyond all praise. These worthy folks imagine that we have been wrecked, seeing that we have fallen so near to our starting-point. In a moment they seize the ropes, and fifty stout arms hold down the *Giant*. One of our companions requests a man to take his place, and jumps out; he sees the Lonjumeau omnibus passing, runs after it, catches it, gets in, and will probably be in Paris before the crowd has left the esplanade! Having nothing better to do, we follow his example, carrying off our scientific instruments, which have been paraded above, but have never been out of their cases. A multitude of peasants run up and storm the car. Although the balloon is half empty of gas, it still offers an enormous surface to the wind; a brisk puff of air blows it down, and the car, which had rested upon a slope, turns over at the same time, throwing all the new-comers out pell-mell one on the top of the other. Our *rôles* are thus changed; *we* run now to help those who came to help us! In spite of this incident no enthusiasm is lost, and it would be easy to collect from the bystanders four times the number of persons that the balloon could carry, were there any gas left, so eager were they to experience the effects of an aërial voyage. Such an equipage would certainly not cast anchor in sight of port!

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SECOND ASCENT.

The *Giant* was about one month in getting over the effects of this first excursion. During this time Paris was covered with immense placards announcing to the astonished inhabitants that a marvellous experiment was about to be made. I had sworn that Montlhéry should not this time be my last mile-post! Simonin was also to be relied upon. On the day of the ascent it was nearly four o'clock before enough gas could be introduced into the envelope to cause the balloon to show some signs of impatience. It is inflated as much as we dare with patience allow: its vast dimensions favour the notion that its ascensional power is amply sufficient for a very long journey. The car contains six persons only, and the learned people who remain behind on the ground have not favoured us this time with their great copper ice-house. How secure we feel; and what hopes!

The balloon is striped like a zebra: long bands of white silk sewn with black thread go quite round it, and cover some of the wounds made in the Lonjumeau excursion, producing quite an artistic effect upon the brown tint of the old veteran. Will the wind carry us to Prussia, and shall we have a second Hanoverian campaign? In spite of our late unfortunate adventure, I am full of enthusiasm, and approaching the victor of Königsgrätz, who happened to be present at our departure, I ask him if he has any message for his brother the King. I had reckoned on the weathercock, but without the balloon, as our readers will soon perceive.

The formal "let go" having been pronounced by M. Camille d'Artois, the aërostat was found to be very weak indeed; it appeared likely to fall to the ground again at once! A few bags of ballast were immediately emptied upon the heads of the spectators outside the reserved places, and produced an excellent effect. The balloon rose just as it was about to rush into the trees of the esplanade, when we should have been wrecked on the spot!

The car alone receives the shock; a few branches are broken off and carried into the air—a fortunate but costly trophy.

This little incident, which must appear frightful to the spectators assembled beneath, nevertheless excites the sympathy of the crowd, and a salvo of applause reaches our ears.

The houses soon become smaller, and the largest palaces appear of lilliputian dimensions. As for the Tuileries, it might go into our pockets. The column on the Place Vendôme looks like a pin stuck

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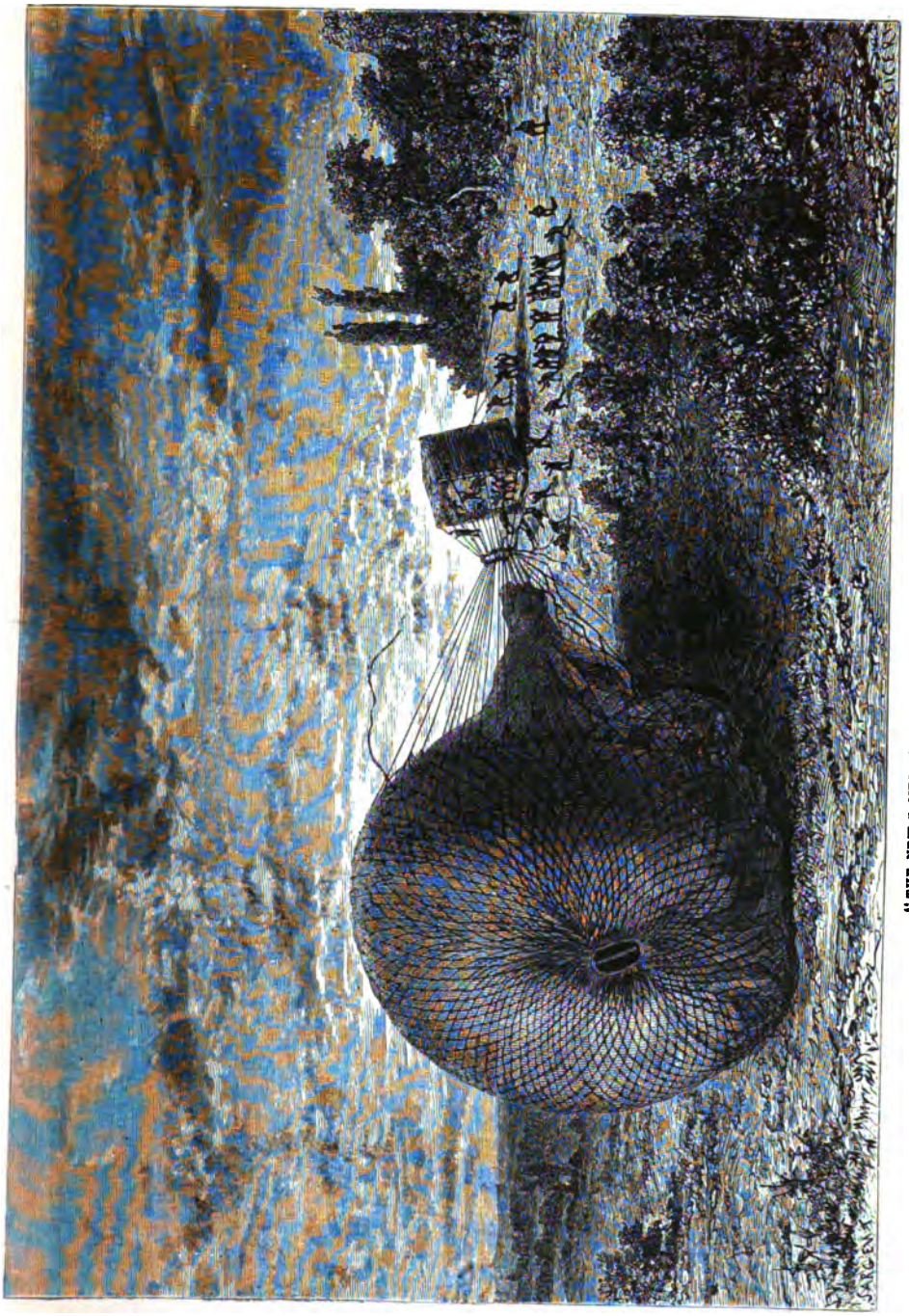

"THE NEW-COMERS FALL, PELL-MELL, ONE OVER THE OTHER."

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UNIV. OF MICH.

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head downwards on a cushion; and as for the obelisk, it may be well called Cleopatra's needle.

We are not long to enjoy this bird's eye view of the capital, for the inflection of the silk bands of the envelope points to the fact that we are descending very rapidly. A large quantity of ballast is thrown out, and hundreds of trade circulars confided, by handfuls, to the winds.

Light papers, feathers, and small parachutes might be sometimes used instead of ordinary sand as ballast; they form a perfect cloud around us, and mark out, with wonderful precision, the aërial route along which we travel. When they fly about over our heads, it must not be imagined that the wind carries them up; on the contrary, we are descending more rapidly than they are.

A few more bags of sand, somewhat promptly sacrificed, cause us to gain a certain amount of ascensional force, and the sheets of advertisements appear to fall like so much lead. At last we have triumphed over the loss of gas which rendered our balloon heavier every moment since we started.

If the open end of the tail were closed with a valve, which would only be opened in case of danger, our veteran *Giant* would soon be enabled to make a long journey and outstrip the little *Imperial* balloon, which has risen from the Hippodrome and follows the same current of air. But this opening remains gaping widely, in spite of the efforts of M. d'Artois to make its surface smaller. Moreover, it is fissured, and as the aërostat rises the gas issues from the fissures; when we sink, air enters the balloon by them and increases our weight. The difficulty of remaining some seven or eight hundred yards above the surface of the ground increases every moment. We have no more advertisement bills, and our sixty bags of ballast are reduced to sixteen. Nevertheless our descent continues; the sixteen bags of sand are reduced to five, and finally the whole five are bundled out into the air.

This last achievement has certainly produced some effect; we appear to stand still for a moment; but after turning or pirouetting once or twice upon itself, the balloon sinks through the atmosphere like a diver who has plunged head foremost into the water.

At this moment we are, according to the barometer, about 1,300 feet high.

The current of air produced by our rapid descent is like that felt upon a locomotive. The air seems to become solid; it is not firm enough to support us, but will soon be strong enough to stifle us. The silken bands are torn, objects on the ground increase rapidly in

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size, the two grapnels luckily have been thrown overboard, and the guide-rope already touches the ground. At last the shock comes. . . . I leap with all my strength and cling by my hands to the hoops . . . . Another shock, less violent than the first, but quite strong enough. . . . The grapnels hold fast; we all hang on to the valve-rope; the captive balloon empties itself of its gas, and descends slowly on our heads.

The instruments are all broken; one of the travellers has his face covered with blood, another has been wounded by a thermometer, and a third complains of a pain in the leg.

In less than one minute we have travelled along a vertical line a distance of some 1,300 feet. As the air could no longer bear our weight, the brave *Giant* had extended itself and formed a kind of parachute. . . . A weight of some 7,000 or 8,000 lbs. avoirdupois had thus fallen to the earth with the speed of an ordinary railway train, and without any accident that would be remembered three days afterwards, and all this thanks to the guide-rope.

Whilst the balloon was being emptied I examined the envelope and discovered two large openings, the edges of which were as neat as if they had been cut with a hatchet. How were they made? I cannot say with certainty, but it appeared most probable that we owed them to the trees on the esplanade. At least I flatter myself that such was the case.

We had fallen near the Northern Railway, in the garden of the Collége de Juilly, the inmates of which kindly invited us to dinner; but having met an acquaintance on the ground, we dined together on some of the provisions in the car. I slept at an excellent hotel, and next morning was stupid enough to take a cab back to Paris. This wretched machine overturned in a wheel-rut and nearly broke my bones. However bad my aërial vehicle was, it was certainly preferable to this horrible concern!

THIRD ASCENT.

Guyton de Morreau, the first director of the Ecole Polytechnique, plays a great and glorious part in the history of aërial navigation. He was the author of the first scientific attempt to govern the motion of balloons; he organized a body of aëronauts, who in their very first exploits saved a French army when in a most critical position.

Napoleon I. no more understood balloons than he did the use of steam as applied to maritime navigation. He treated aëronauts as he

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did Fulton; so he had no Fleurus aërostats among the baggage of the Imperial army when the day of Waterloo dawned and his eagle eye mistook Blücher for Grouchy.

The day of the 16th August, 1867, is remarkable for the attempt made in France to renew the existence of the Aëronautic Company created by Guyton. The Aëronautic Society of France presented the Parisian public, on that day, with a body of some forty volunteers, recruited among the members of the learned professions and intelligent artisans.

These young men were dressed in a white blouse, on the breast of which was embroidered, in red worsted, a small balloon; and a similar ornament garnished the caps of the non-commissioned officers. For three or four hours at a time these volunteers exercised themselves with a captive balloon placed at their disposal, and doubtless many of them would some day have rivalled our most renowned aëronauts.

The public soon manifested the desire to take part in these ascents, and several persons were content to pay four pounds sterling for the pleasure of a short excursion in the car. Thousands of spectators used to come and witness their ascents on the esplanade of the Invalides; but, alas! this rising body of aëronauts seems to have disappeared altogether. Even their balloon has been taken from them. This balloon was the *Imperial;* it was to serve as our *estafette* in the present instance, and started before us. The captain of the *Imperial,* on this occasion, was M. Gabriel Mangin, who had already made a considerable number of ascents. The proprietors of the *Giant* supplied the gas, but the expense was met by the sale of tickets at 100 francs (4*l.*) each. Moreover, Mangin had been made to promise that his balloon should descend as soon as the monster *Giant* returned to the earth. No one was allowed to remain in the air longer than the said *Giant;* it was quite humiliating enough to see the *Imperial* balloon, which was seven times smaller, carry its three passengers so buoyantly, whilst our enormous balloon could only carry nine, without alluding to the fact that we were outstripped! On no account was the *Imperial* to stay all night in the atmosphere, as it was decided that the *Giant* would go to bed early.

The aëronauts of the *Imperial* kept their word, and descended at a few thousand yards from the point where we descended also.

Formerly it was the custom to make double, and even triple, excursions. Green assures us that he often sent up three balloons at once, and that they sometimes spread to a considerable distance from each

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other; sometimes, however, this was not the case. On such occasions the determination of their apparent diameters, when at various heights, by means of a telescope, would tell us their respective distances. The inclination of the visual ray to the vertical would give the second element of a right-angled triangle, the unknown side of which would express the difference of height; and these indications might be confirmed by the observations of the barometer taken in the balloon. Whilst indulging in these ideas, I perceive the balloon which accompanies us, and, forgetting that it is the same current of air which carries us along, I cannot help thinking we are racing: for the spirit of rivalry is ever awake or at hand, and always sleeps with one eye open!

We were nine passengers on board the *Giant*, two of whom paid a thousand francs each for their excursion. One of them was a gentleman from Marseilles, full of enthusiasm, and so intent upon making this voyage, that we rather suspected he had determined upon throwing himself out, and we considered the consequences of such an act. In a small balloon a man less would make a sudden and dangerous change of weight; but in an enormous balloon like the *Giant* the loss of an individual weighing about 10 st. would only cause a rise of about 800 yards. When Green let Cocking descend in his newly invented parachute, he nearly met with a fate as disastrous as that of his imprudent friend. Though he pulled the valve-rope lustily, he rose at once into the icy regions, where Zambeccari lost his fingers from the effects of the cold.

The other individual, if he had been obliged to pay by weight, would have had to hand over at least two thousand francs. However, he was an engineer, and did good service in noting the barometer and thermometer. He had only one fault, that of believing in the forty-six hours promised him for this excursion by the proprietors of the *Giant*. The brothers Louis and Eugène Godard had the management of the balloon, and it cost us no less than forty-six bags of ballast to attain an altitude of 9,840 feet, without counting that which was let out gradually to keep us at this height as long as possible, and to prevent the balloon falling with rapidly increasing velocity to the earth. Such accelerated velocity is a terrible thought in the mind of an aëronaut; fancy a bird forgetting to open its wings, and coming to the ground like a stone!

About eight o'clock dinner is thought of; for the pure air of the higher regions gives us a prodigious appetite. We had chicken as our first and last course, and our plates were newspapers. We had no champagne: an unwary cork might have shot through the envelope;

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"'IT'S THE GIANT SMOKING HIS PIPE,' SAID SOME ONE."

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but we had soda-water and Bordeaux, the former of which went off by itself at these great heights, and shot out its cork as coquettishly as if it had just left the hands of Widow Clicquot.

At dessert we were rather gay, and our joviality would have continued somewhat longer had not a most extraordinary phenomenon occurred just as we were taking our coffee.

The *Giant* is a very hygrometrical balloon, and ever since its departure it had been floating in a very damp atmosphere. A considerable quantity of vapour had condensed upon its surface, perhaps some two hundred-weight in all. A little before nine o'clock the wind carried us into a drier region of the air, where the moisture which was condensed on the balloon began to evaporate very rapidly, and, instead of its tendency to sink, the aërostat remained fixed for a time at this altitude. Soon after this we noticed that it became more inflated, and its shadow in the clouds seemed to get further away from us. The barometer showed that we were about 10,000 feet high, and the temperature, which had been very mild, got much colder.

The surface of the earth only appeared now and then through the openings in the clouds which rolled along at a distance of 3,280 feet below our car. Jupiter was shining with singular brilliancy in spite of the strong moonlight, our satellite being only ten degrees from the planet. The most conspicuous stars, on the contrary, shone with a very feeble luminosity, so much so that I could scarcely distinguish those of the Great Bear. To the west, large black masses of cloud, lighted up by the moon, floated in the air like basalt rocks capped with snow and ice.

At this moment one of the travellers, M. Simonin, drew our attention to a white smoke which appeared to issue from the sides of the great balloon, something like the steam that issues from the funnel of a locomotive. "It's the *Giant* smoking his pipe," said some one, laughing at the occurrence. But it was no laughing matter; this pipe was being smoked over a barrel of gunpowder. In fact, the gas, which issued in volumes from the neck of the balloon, was driven out by a sudden dilatation, and was evidence of a great internal strain that might split the envelope, which, though formerly so tough, was now like so much tinder. Had the balloon burst at such a height, we should have been precipitated to the earth with a velocity three or four times as great as that with which we landed in the gardens of the Collége Juilly; and instead of being broken to pieces, we should have all been reduced to the state of pulp.

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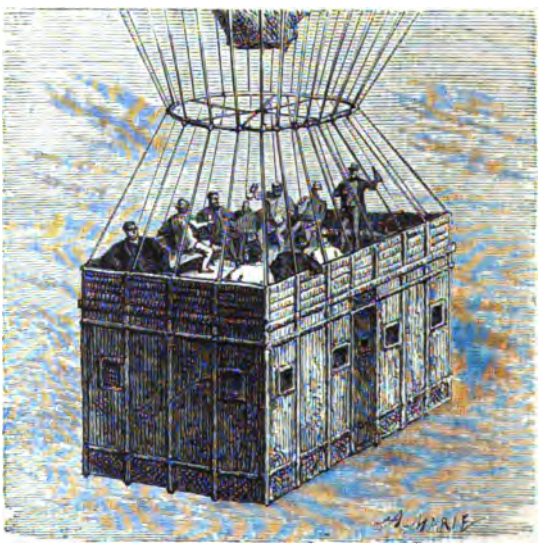
After the apparition of the smoke, silence reigned among us for a moment; we all looked up to see if the escape of the gas, which had been suspected for some time past, would play us some unpleasant trick, and cause us to fall by our own weight! . . . .

The next morning we took a cut to the nearest railway station, and left the aëronauts to collect the remains of the balloon. We were rather disappointed, especially the gentlemen who paid, not to have passed the night in the air. But an incident which occurred put us all in good humour again. At the first station at which we stopped on the way to Paris, we fell in with the aëronauts of the *Imperial*, and fraternized with them at the next refreshment-room. It was a singular sight for the other passengers in the train, to see aëronauts drinking with aëronauts. But though aërial fraternity is a great thing, doubtless, upon the earth, it is in the higher regions of the air that we should be on good terms. My friend Tissandier and myself have long had the idea of joining two balloons together by a long rope—and we hope we may yet try the experiment.



BREAKFAST IN THE CAR OF THE "GIANT."

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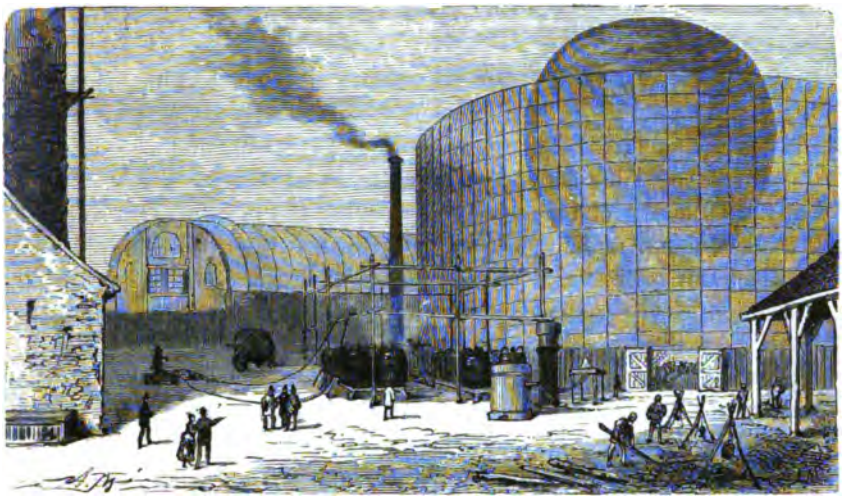

INFLATION OF THE CAPTIVE BALLOON AT THE EXHIBITION.

CHAPTER II.

THE CAPTIVE BALLOON AT THE EXHIBITION.—THE FALLING STARS.

(W. DE FONVIELLE.)

In spite of its triple failure, the *Giant* balloon has perhaps rendered some slight service to the art of aërostation. It might have done more had it been capable of making excursions of some twenty-four hours' duration. But several causes impeded its career. The makers of this balloon thought proper to give it a double envelope; a system formerly proposed by General Meusnier. A scientific object was aimed at by the learned General. He proposed to make the external envelope rigid and capable of supporting great pressure, such as that of air forced in by a pump, so that hydrogen gas might be compressed into the balloon, and the latter caused to act like the air-bladder of fishes. But the idea was never practically carried out, and the unfortunate Meusnier was killed upon the battle-field before he had time to realize it.

However this may be, the failures themselves have had the effect of directing attention to this subject, and notwithstanding the indifference shown by great men to the question of balloons, many people believe in the possibility of guiding them. Among those who have devoted considerable time to aërostatics we should mention M. H. Giffard, the well-known engineer, and inventor of the *injector* for feeding steam-

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engines. Twenty years ago, when this gentleman had just left the Ecole Centrale, he made an ascent from the Hippodrome all alone, and in an elongated balloon carrying a steam-engine and a screw. He certainly caused his aërial apparatus to execute certain movements, but the difficulty of balancing and working the machine was so great that he did not remain long in the air; his descent was rapid and perilous, but fortunately without any serious accident.

Though M. Giffard has realized a large fortune, he still takes great interest in these matters, and turned his attention not long ago to captive balloons, and made several experiments with them at the time of the French International Exhibition, when he had a captive aërostat of some 176,500 cubic feet capacity.

In order to fill this enormous balloon with hydrogen gas, it was found necessary to use no less than 60,000 lbs. of sulphuric acid, 30,000 lbs. of scrap iron, and an immense quantity of water. The decomposition of water by red-hot iron was also tried, as had been done before by Republican aëronauts when chemistry was in its infancy; but it was found to be a very laborious operation, though so simple in appearance.

Among other improvements suggested during these trials was that of adjusting safety-valves to the neck of the balloon in place of the wide opening now existing, by which the gas enclosed in the envelope is being constantly mixed with atmospheric air. We think this improvement well worthy the attention of engineers.

The captive balloon at the Exhibition appeared impatient to render some service to science. Already it indicated the direction of the wind with marvellous precision. Moreover, the variable tension of the dynamometer measured equally well the force of the wind, whence it is easy to calculate its velocity, an element of great meteorological importance. It would have been interesting to see M. Pasteur repeat his Bellevue experiments by carrying up his glass balloons in the captive aërostat; and several other aërial researches suggest themselves forcibly to the mind; but the day of captive aërostation has not yet arrived.

The day on which I made my ascent in the captive balloon I had the good fortune to meet the well-known M. Jacobi, of St. Petersburg, in the car. He had never made an ascent before, and assured us that his head was affected when he looked from the top of a high building, but in the balloon he experienced nothing of the kind. The first words he said on landing were, "The guiding of balloons is much nearer to us than is generally thought."

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A poet has imagined that if the rope of the captive balloon were to break, the journey of the inmates of the car would be a long one. He was mistaken; the voyage would be very short, perhaps too short to please the excursionists, for the aëronaut who always accompanies the visitors would at once pull the valve-rope, and the loss of gas by this valve, aided by the automatic action of those in the neck, would soon bring the aërostat to the earth. The loose rope hanging below would act, to a certain extent, as a guide-rope and moderate the fall.

We made a nocturnal ascent one evening that will long remain imprinted on my memory. We were accompanied on this occasion by several ladies, not one of whom experienced the slightest alarm. M. Serrin had placed an electric light at the foot of the cable, and its rays were directed to the balloon by means of a reflector. Thus illuminated, the *Captive* appeared like a great meteor in the air, and the crowd of persons promenading in the Champs Elysées imagined it to be some strange celestial phenomenon.

For some time past I had cherished the expectation of observing the interesting phenomenon of falling stars from above the region of the clouds by means of a balloon. When the aërostat pursues its silent course through the air on a dark November night, it must be indeed a most interesting moment to the traveller when hundreds of these small meteors dart across his path—luminous atoms, celestial fires, wandering through the immense regions of the atmosphere.

Having made my wishes known to M. Giffard, he generously placed at my disposal, in November 1867, a small balloon called the *Swallow*, which was then in excellent condition. Its car had never carried more than two persons, having been formerly used for certain acrobatic exhibitions of short duration at the Hippodrome, which the police had thought proper to put a stop to. We therefore determined to inflate it with hydrogen gas, to render it capable of making longer journeys.

For this purpose we had recourse to a new apparatus, and the remainder of this account will show how dangerous it is to count upon the success of a new process on an emergency like the present, when time is scarce.

The process in question consisted in decomposing steam by red-hot charcoal. The chemical reaction which occurs between these two substances has been long known, but it has not yet been utilized in the arts. The steam is produced in a kind of boiler heated by a fire underneath, and passes over charcoal in a state of incandescence.

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Though two fires are necessary in this operation, the charcoal and coal consumed are less costly than the iron, whether the latter be acted on by sulphuric acid or by steam. But carbonic acid is produced as well as hydrogen, and has to be absorbed by passing the gaseous product through lime; often carbonic oxide is produced also, and is very much more difficult to get rid of. The large amount of the latter gas produced on this occasion caused a serious and most inconvenient delay in my ascent to witness the meteoric stream of November. Had this carbonic oxide not been formed in such quantities, I should have risen just as the phenomenon in question was at its maximum of splendour, as it was, I was obliged to be content with the end of the celestial spectacle.

Before inflating the balloon we wished to ascertain the ascensional power of the gas we had manufactured, and filled a small balloon with it, which a workman held in his hand whilst a pair of scales was being brought. This man unfortunately allowed the gas to get into his lungs, and swooned. Every one thought he was dead, and that the gas was poisonous; and all the workmen immediately ran out of the place, so that when I returned in the evening with my meteorological instruments, I found the place entirely deserted! I could have wept with rage.

I took a rapid glance at the gaspipe of the establishment, to see if it were wide enough to inflate the balloon in a short space of time. I inquired if the aërostat would be taken to the gasworks. I consulted my watch anxiously. The time had fled; the sky had become overcast, and the falling stars would at this moment have been at their maximum. There was nothing to be done, but to hope that the next night a few scattered meteors might still be seen from the car of the now useless balloon.

The following day M. Giffard determined to prepare the hydrogen gas by the ordinary wet method, by means of the apparatus which he used for his captive balloon. What a pity it is that this apparatus exists no longer at Paris, and that in the whole city there is not a single spot where a large supply of hydrogen gas can be obtained at a short notice or on an emergency!

This time the specific gravity of the gas was so low that three persons instead of two could be accommodated in the car. We took plenty of provisions, coats and rugs, a fine telescope belonging to the Commandant Laussedat, a Richard barometer, a metallic thermometer, and a celestial map by Dieu, on which I had marked with care those regions of the sky which were to be particularly examined for meteors. All these were heaped pell-mell into the car of the

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aërostat, which was not very unlike a baker's basket, and scarcely any larger.

On this occasion the American aëronaut, Wells, wished to accompany us. He could not speak a word of French, but he caused me to understand that if we desired to go higher and to get rid of his weight in the car, he would descend at once in his parachute, so that we could soar up towards the meteors. Several newspapers have announced that Wells was killed near Milan, by the rupture of his balloon. The fact is that, having cut the rope of his captive balloon, he ascended with great rapidity, and thus the envelope, which was old, split up from the effects of the rapid dilatation of the gas. An enormous opening was thus produced, and the balloon fell rapidly to the earth; but Wells, being accustomed to the use of a parachute, arrived safely on the ground.

We rose punctually, about the time when most people think of entering their box at the opera; and now enjoyed the sight of Paris illuminated beneath our feet by innumerable stars, arranged in a very different order from that of the heavens. The spectacle was grander on this occasion than in my previous nocturnal ascents. The lamps along the quays, more especially, produced an admirable effect, and those in the streets formed innumerable lines of fire crossing and recrossing each other in all directions. The temperature was exceedingly mild, and I was obliged to throw off my overcoat.

At forty minutes past twelve we were able to recognize Enghien, where I heard my friend Simonin lecture on behalf of the expedition to the North Pole proposed by Lambert. The receipts were 37fr. 50c., whilst those at a public ball in the neighbourhood amounted to more than 1,000fr.

At one o'clock our pilot saw one shooting star, which the astronomers on the earth's surface certainly did not see: we were then 1,600 feet high, and I was beginning to feel the influence of the purer air of the higher regions.

Night appears to us a very favourable time for making balloon ascents; there is no dilatation of the gas by the sun's rays, and the atmosphere is generally calmer: besides, there are many physical observations that can be made when there are no shooting stars; such, for instance, as the light of the Aurora Borealis, or the zodiacal light, &c.

After leaving Enghien we approach the Northern Railway, and the wind carries us, at the rate of fifteen miles an hour, in the direction of Chantilly. Whenever we pass over a wood or a coppice we

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frighten out the crows and the nightingales. All animals seem to be frightened at a balloon.

The noises which reach us from the earth are few, but very varied, and call up a host of thoughts and recollections which form not one of the least charms of these nocturnal excursions.

The following notes were made during the voyage :—

We hear a church clock strike one, which proves that we are getting near to the ground. The barometer stands at 27·95 inches.

2 o'clock.—We hear the cocks crow. The crows seemed frightened at us, and presently fly off precipitately. The barometer stands at 29·21 inches.

2h. 20m.—We hear some peasants call out "There's the balloon!" but we cannot make them hear our shouts. It may be that they answer us, but their words are slow to reach us as we are carried off by the wind. Instead of asking people where we are, it is perhaps better to rely upon what we can see and what we hear by accident. The barometer is now at 29·10 inches.

2h. 25m.—We hear distinctly the music of a village ball; it must be a marriage ball, or every one would be in bed at this hour. The barometer marks 29·06 inches. The wind is getting stronger, and, rushing through the woods, produces a noise like that of ocean waves. We are sailing above an extensive forest. If the wind continues so strong, we shall be carried over the border into Belgium by about four o'clock. Heaven alone knows where we shall stop! We have not used 20 lbs. of ballast per hour since we started; we have therefore enough left for ten hours more at least, without reckoning upon our seats, bottles, instruments, greatcoats, and the heat of the sun's rays in the forenoon. We have just demolished a chicken and a bottle of wine.

The celestial vault as seen from the car of a balloon offers a peculiar charm to me, which it is quite impossible to describe; the spectacle it presents can never be forgotten. On the night of the 14-15th November the moon had passed its full, the shadow had already spread a little upon the edge which is turned towards the west, but the high summits of the Cordilleras had not yet quite sunk into the shadow; at least so I thought when I examined them attentively through the telescope of the Commandant Laussedat. These summits appeared to shine like a chaplet of pearls. Are they capped by perpetual snow, or are they virgin rocks which no water has ever moistened? I cannot say what beings may people this world which our globe appears to have bound to itself; but neither Fourier nor the whole of the French Academy will ever make me

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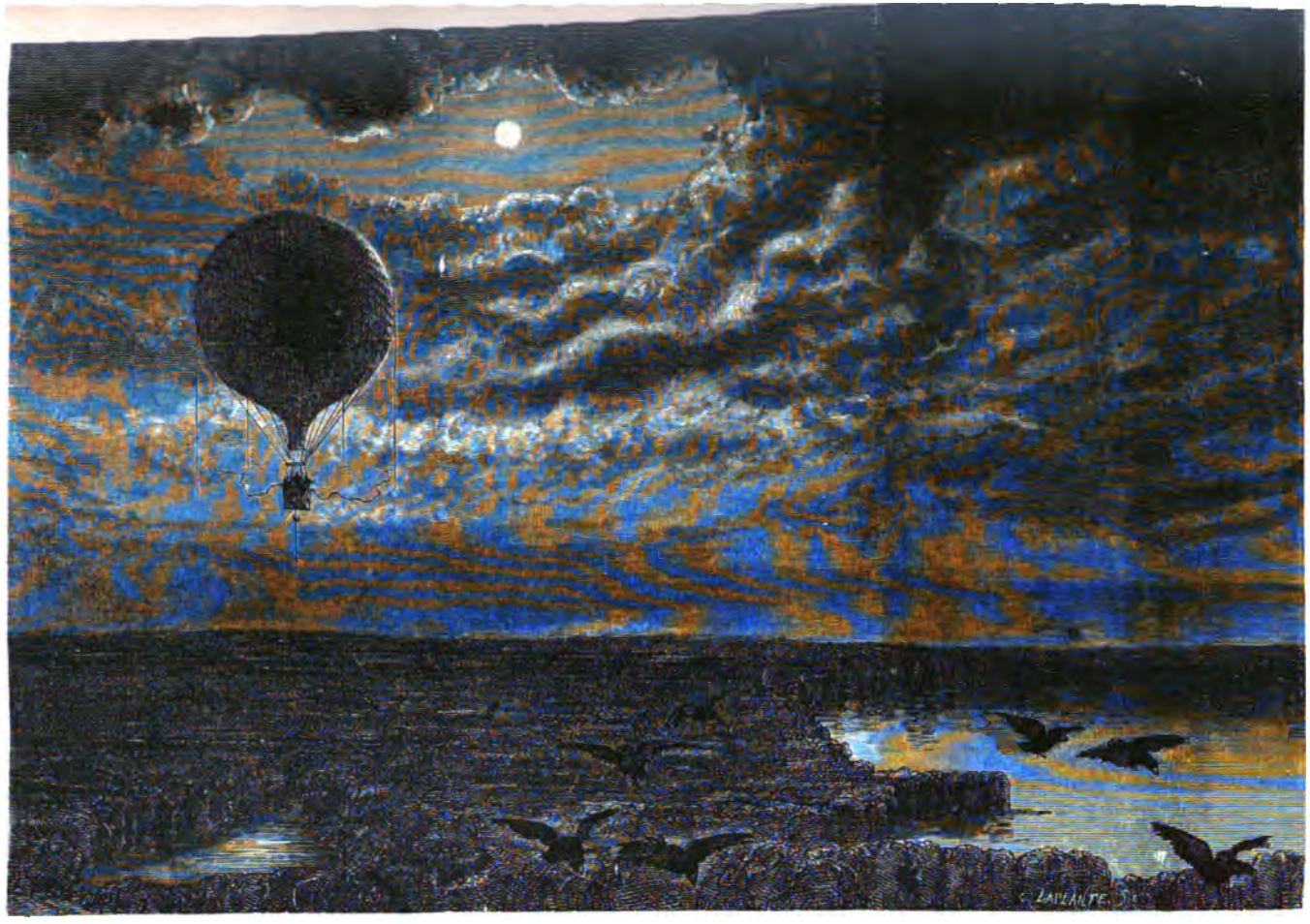

"THE CROWS SEEM FRIGHTENED AT US, AND PRESENTLY FLY OFF PRECIPITATELY."

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believe that this is a desert and an inanimate globe which follows ours in its track through space. Who knows but what the moon may be peopled by a race of beings more intelligent than ourselves, and who may some day conquer us as Columbus conquered the Indians of South America? Is it true that the moon acts upon our reason more powerfully than upon the waters of the ocean? Is it true that it dissipates human reason and the gay projects of lovers, as, to-night, it hides from our gaze the trains of the meteors? No; let us banish from our thoughts these relics of superstition, and fear no longer to contemplate its soft white light!

A light cloud veils the depths of the firmament, but it has nothing of that coarseness so common to the clouds nearer to the earth's surface. If large meteors should pass, we cannot fail to see them. We have economized our ballast, and do not attempt to rise far from the ground, and so have been able to appreciate the extraordinary influence exerted by the slightest undulations on the earth's surface upon the direction and intensity of the wind. An extraordinary stillness reigns in the valley, whilst the breeze whistles along the slopes; and the forests have a no less singular effect upon the wind.

As we follow the bed of an aërial current which carries us away from human habitations into deserts and sterile places, we ask ourselves how it is that we sail away thus from spots beloved by man—how is it that we see so few lights on our horizon?

It is because the inhabitants of the provinces over which we soar have instinctively built their houses and villages in these sheltered nooks, in spots which are naturally protected from the wind and the weather. In doing this they were not guided by the dynamic law which governs the movements of the atmosphere, but by instinct and experience that has come down to them from father to son for centuries past. Exception must be taken, doubtless, for certain towns built in exposed situations, for the purposes of war, or to obey the caprices of some despotic ruler. But these artificial agglomerations of dwellings are always sad and suffering. Versailles, Madrid, St. Petersburg, will doubtless be exposed for many years yet to the scourge of the tempest and the wrath of the winds.

Whilst occupied with these reflections, time passes by rapidly. We see down below something like vast mirrors spread along the surface of the ground. They are still pools of water upon the peat bogs, and the moon reflects in them her silver visage. So damp a country as this cannot be many miles from the ocean, and effectively we are now sailing over the department of the Somme.

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A few shooting stars are seen at this moment. The balloon revolves again and again, trembles, and shudders. . . . We fancy we see a fire on the horizon.

The wind, which had got calmer during the last few minutes, now freshens again, and causes the balloon to revolve rapidly on its axis, so that we cannot, at first, discover in what direction the said light or fire is seen. At one instant I fancied it was the light of the sun announced in the east by Venus, in spite of the astronomical data for the month. The damp has penetrated our network, the cord of which has sucked it in like a sponge, so that we must throw out a little more ballast if we wish to compensate for this increase of weight. If the light seen were really the sun, it would soon rise and drive back this moisture into the clouds from whence it came, and lighten our balloon by dilatation; so that we should rise without losing a grain of sand. But I now perceive that the Great Bear shines out again, and that the light I noticed is in the west—not to the eastward. Moreover, it is not a single, but a double fire. . . . They are twin lighthouses on the coast. . . . Then we are approaching the sea, there can be no doubt of it.

The question is, are we in Belgium? Shall we come down? It will never do to risk a journey over the ocean, though we have still 120 lbs. of ballast, plenty of rugs and coats, some provisions, and a bottle of water. Our engineer prepares his knife to cut the rope that holds up the grapnel and the guide-rope, and tells me to bear on the valve-rope. I obey his orders most conscientiously, for we cannot be more than three-quarters of a mile from the coast, and a minute or two more, with the wind that is blowing, would perhaps take us right into the water.

Scarcely twenty seconds had elapsed since I laid hold of the valve-rope when I felt a shock which formerly I should have considered very violent. The grapnel had fastened itself to the ground, and the high wind caused our balloon to pitch over on one side, so that we had to hold ourselves in the car by the ropes. But shortly afterwards the balloon got free again, and bounded away . . . . the loss of gas told upon these bounds . . . . and soon we placed our feet on *terra firma*.

With great precautions I deposit my traps inside the car, and then we press down the balloon by hanging on the network, after having unscrewed the valve, so as to get the remainder of the gas out of the troublesome thing. The gas issues out into the air in volumes, and we smell its peculiar odour around for some time. At last the balloon is empty, and we stand round the deserted car,

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FALLING STARS AS OBSERVED FROM THE BALLOON

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THE PEAT BOGS OF LA SOMME, SEEN FROM THE CAR OF THE "SWALLOW.

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looking each other in the face until one of us exclaims, "Where the deuce are we?"

The lighthouses above mentioned, even if they be now extinguished, could leave no doubt about our being near the coast. Still, we have no sound of waves breaking against the shore: perhaps the tide is low. The ground is damp and stiff where we have alighted; the fields are covered with small ditches—excellent for allowing the surface water to escape, and also for giving sprained ankles.

After jumping about over these ditches, first to the right, then to the left, for upwards of an hour, luck appears to favour us, for we hear the lowing of a calf! There is some one in the neighbourhood, then; for it is not likely that the wind has carried us so far from thieves and vagabonds as to have allowed us to descend from the skies near to a stall where calves low alone, guarded by Providence!

The cowherd wakes up less easily than his calf. His comprehension of what we tell this sleepy Picard is still slower: although the Treaty of Commerce has put an end to smuggling, he cannot believe that we are honest folk. It is not astonishing, however, that he should have kept his door ajar only when he heard us ask "Are we in France?" and he replied, closing it almost entirely, "Parbleu! what a question! Aren't we in the Pas-de-Calais?"

However, when he was so far awakened as to hear the rattle of some franc-pieces in the hand of one of my companions, the brave cowherd decided upon opening the door wide enough to pass his hand through; and when he felt that the coin had changed masters, he opened it altogether, and volunteered to conduct us to an inn about two miles off, where we could procure a cart.

On the road we learnt that the lighthouses we had seen were those of Touquet; and that the railway station of Etaples was not far off. The honest cowherd informed us mysteriously that there was a depôt of police there. He also assured us that commerce was making rapid strides in the port, no less than *two* ships having anchored there last year. Under his auspices we were well received by the host of the inn, whose bright-eyed daughter served us out a bottle of wine with somewhat of a cider flavour, and asked us naïvely whether a balloon sailed on the water or rolled along the ground.

We find that we are not more than six miles from the forest of Guiennes, in the midst of whose fine trees rises the monument erected to Blanchard on the occasion of his first passage over the Straits of Dover in a balloon.

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The honest cowherd now comes and tells us that the horse and cart are ready, and that we can go and fetch what we want, winking his eye in an ominous manner to the host as he says it. He appears to think that we have got something in the Downs which we do not care to pass through the custom-house, or to show to the Mayor of Etaples.

After several long windings about, we come finally, at about a quarter to eight o'clock, to the spot where we left the balloon. The poor little *Swallow* is by this time as flat as a pancake, and we can scarcely find it. On coming up, a sportsman is contemplating this new kind of game, and his two dogs have devoured all our provisions, excepting a small piece of cheese and the end of a sausage.

The host of the inn, who has accompanied us to the spot, cannot understand the use of the car. He believes that aëronauts travel in the inside of the envelope, where they are protected alike from the sun and the wind; at last I succeed in convincing him that the car is at least our travelling-box, where we keep our provisions, &c.

In the course of half an hour the balloon and its car are safely packed into the cart, and at half-past nine we make our triumphal entrance into the railway station at Etaples.

The various clerks and officials were very polite to us; but—can it be believed?—when we wished to pay for our luggage, there were no scales large enough in the station to take the weight of the little balloon. However, it must be weighed or left behind, which our aëronaut would not hear of. He vowed and declared that the whole machine weighed exactly 560 lbs.; they would not believe it. At last an old weighing-machine was discovered at the end of the station, and the weight of the *Swallow* without its gas duly registered; our aëronaut was only wrong by 4 lbs.

We had a long, dreary ride back to Paris, the counterpart of the pleasant journey we had had through the atmosphere.

All our instruments were safe, and none of us had received the slightest scratch, in spite of our rapid descent in a high wind. This sudden descent must be ascribed to the use of hydrogen instead of ordinary coal gas. The specific lightness of the former is such that when the valve-rope is pulled, for every cubic metre of gas which escapes, the balloon gains more than two pounds in weight, instead of three-quarters of a pound only. Therefore the increase in weight, when hydrogen is used, is two or three times as rapid as with street gas. The latter should therefore be used by those who commence the art of aërostation, as it is much more easily managed.

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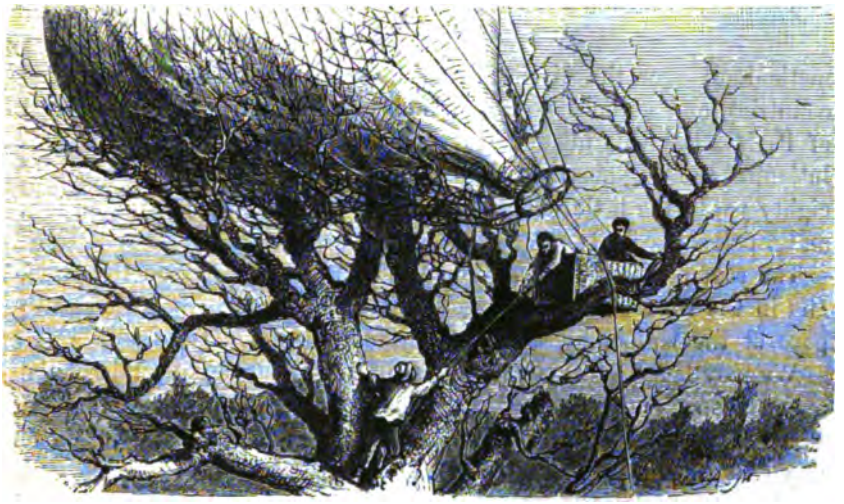

"A PEASANT SUCCEEDS IN CLIMBING UP TO US."

CHAPTER III.

THE "ENTREPRENANT" BALLOON—VOYAGE FROM PARIS TO FERRIÈRES

(W. DE FONVIELLE.)

"A GOOD captive balloon, and a photographic apparatus with reversed objective, constitute the whole of my apparatus," writes M. Nadar.

"No more triangulations," he continues, "based upon a heap of trigonometrical formulæ; no more of those doubtful instruments called theodolites, compasses, alidades, graphometers; no more chains to be lugged about by surveyors (as if they were galley-slaves) through cultivated fields, vineyards, and morasses alike!

"I, who all my life have held mathematics and algebra in horror, can now produce, with the rapidity of thought, plans which are as faithfully exact as those of Cassini, or as perfect as those in the cabinet of the Minister of War!

"And, after all, what can be more simple? My balloon is held captive at a height, say, of 3,000 feet, over certain points strictly determined beforehand, and by means of my photographic camera I take in at once about a million square yards of surface—let us say fifty to a hundred acres; and I can repeat this operation at ten different stations per diem. This is what I call surveying by photography in the true sense of the term!"

M. Nadar, guided by these sanguine notions, actually patented the

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method all over the civilized world, and even in some barbarous countries, and at once commenced operations in the neighbourhood of Paris. But this gigantic surveying expedition, that was to revolutionize the engineering world, ended in taking, from a height of eighty yards, the little village of Bicêtre, composed of a farm, an inn, and a police station!

The roof of the police station came out very clearly on the proof, and in the road we have a peasant boy who has stopped his cart to gaze at the balloon.

We may laugh at this ridiculous attempt, but why should not the art of Niepce and Daguerre join hands with that of Montgolfier and Pilâtre? Why should we not map out the heavens in the same way that M. Nadar surveyed, photographically, Petit-Bicêtre? What would not astronomy gain if it could get rid of the clouds and dust of the lower atmosphere![1]

Could not instantaneous photography be combined also with observations of this description? Could not the Earth be photographed from an enormous altitude, as Warren De la Rue has photographed the Moon?

With these ideas in my brain, I determined upon organizing a photographic expedition in a balloon in order to observe an eclipse which was to take place on the 23rd of February. It was no easy matter to find a photographer who would condescend to accompany me. At last one of moderate ability decided on making the ascent and his name illustrious, should the expedition prove a success. We had many things in our favour; everything was prepared with the greatest care, and we had passed a great number of evenings together discussing every detail in the management, with the exception of *the* manager, or aërial pilot, to whom we were to confide our fortunes and chances of discovery. We had vainly imagined that a little enthusiasm might perhaps penetrate into his thick head!

I had caused a hole to be made in the floor of the car, in order to take our bearings easily. But at the moment we ought to have started a strong wind sprung up, and the professional aëronaut thought proper not to inflate the balloon. When the eclipse was over, he informed me that he *did* think proper to inflate it, as the

[1] Professor Piazzi Smyth, Astronomer Royal for Scotland, carried a telescope to the summit of the Peak of Teneriffe in 1856, and proved by numerous interesting observations, which he has stated in his little work entitled "Teneriffe: an Astronomer's Experiment," that celestial phenomena are seen with marvellous distinctness in a locality so favourably situated.—T. L. P.

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wind had gone down. But night was approaching, and so I decided to put off the ascent till next day, and then occupy myself with taking photographs of the earth's surface.

When the balloon was all ready for starting, I declared that the voyage should be postponed till the morrow; so we had the car loaded with stones, closed the neck by means of a tight cord, and left it to Providence till morning, having attached it to four iron bars stuck into the paved square of the gasworks.

The next morning I rushed along the Rue Aubervilliers, not without anxiety; but found the balloon all right, tranquilly balancing itself to and fro. There was a considerable crowd of spectators about the place, and a good number had entered the works and surrounded us closely as we made our preparations for departure. However, they all behaved very well; there was only one person among them with whom we had any difficulty, and that was precisely the aëronaut who was to accompany me on this occasion.

After having packed my photographer carefully into the car along with his apparatus, I looked up and perceived an unknown individual who had got himself entangled in the netting, and had opened as widely as possible the orifice of the balloon's neck. Every time the balloon oscillated a flood of gas issued from it. "Hallo!" I exclaimed inwardly, "if I do not mind what I am about, in a few minutes the balloon will not be capable of rising at all. . . . I look round, and find that the professional aëronaut who is to accompany us is absent. On inquiry I find that he has gone for the second time to refresh himself in the public-house opposite the gasworks. I rush across and lead him back to his duty. On coming alongside the balloon the aëronaut tells me that we cannot possibly rise without leaving all our ballast behind. I jump out of the car and tell him to ascend with the photographer; he replies that he can take up the photographer, but not his heavy apparatus. I then turn to the latter, and ask him if he will start with me and leave our aëronaut behind.

The photographer had long hesitated before he could decide upon going up with *the* aëronaut, but the idea of starting with me alone caused an exclamation to escape from his lips. Throwing his hands in the air, he said with the most comical expression imaginable, "Oh dear, no!" I jump into the car a second time, and throw overboard everything I can lay my hands upon; then turning to the aëronaut with my fists clenched and the blood rushing into my face, I exclaimed, "Let's be off!" I was in such a passion that I actually forgot to salute the crowd below who cheered us as we rose into the air.

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We had not risen more than a few moments when the aëronaut informed me that I stood a good chance of falling out of the car, and advised me to mind what I was doing. The car indeed leaned terribly on one side. "How is this?" I exclaimed; "why does this machine lean thus on one side?"

"Because we carry two anchors, a considerable weight of rope, and two guide-ropes."

"But this weighs far more than my photographer and his camera: why on earth do you carry all this useless gear?"

"We always used to do so on the *Giant*," replied the aëronaut.

At this moment I heard a sharp crack up above.

"What!" said I; "surely you are not opening the valve already? As we are in the air, we may as well make a decent ascent." . . . .

"I do not wish to go beyond the clouds; the sun will dilate the gas, and we should rise much too high."

"But I do not wish to come down so soon, either!"

"I believe I am master here," he replied, with a dry sneer.

"So I perceive." . . . .

What was to be done? It would never do to have a quarrel, or perhaps a fight, up in a balloon; I therefore remained quiet in spite of my anger, and observed the curious phenomena that presented themselves as best I could. What with the bad management of the professional aëronaut, who first pulled the valve-rope with a jerk, and then threw out ballast to arrest the rapid descent, and so on alternately several successive times, the balloon bounded up and down some 200 yards at a time, like a large india-rubber ball, and the mercury in the barometer jumped about in like manner. These rapid ups and downs appeared to prevent to a certain extent the rotation of the balloon; and I was once enabled to keep the sun, seen through the mist, for two or three seconds in a fixed position.

We came out of the clouds in about half an hour, leaving them suspended above our heads. The balloon then sank rapidly and turning all the time; but it never made more than 200 revolutions in one direction, for the aëronaut found it necessary to throw out sand to moderate the descent, and as soon as we began to rise again the rotation occurred in a contrary direction. In looking through the hole in the floor of the car, I sometimes saw the ground quite still for the space of a few moments; long enough, I should imagine, to enable an expert photographer to obtain some instantaneous proofs.

Finally we approach the ground, and I perceive the trees of a forest getting larger and larger. Now, thought I, it will be necessary

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to take care of my neck. However, the forest glides away as we sink rapidly down and come directly over a morass. "Into a bog!" I exclaimed involuntarily. "This is too bad!" They were the first words I had pronounced since our late discussion. They seem to have had a certain effect on the aëronaut, who threw out a little more ballast. The balloon rose at once about fifty yards, but sank again almost immediately. The anchor which had been already thrown out caught in the bough of a tree, and then the aëronaut began to bellow out for help. I had no words to express what I felt, so remained quite silent. At last a peasant succeeds in climbing up to us; as soon as he is near enough, I request that he will be good enough to witness the fact that we were caught at the top of a tree with three bags of ballast yet untouched in the balloon!

The aëronaut slipped down the tree, and by means of a long rope which he held tightly in his hands, he then pulled the balloon along like a child's kite to a spot where there were no trees, distant about 200 yards, and where he might have made his descent if he had been expert in his art.

We finished the day at a public-house, where I decided, whilst devouring an omelette and certain accessories, that in future I would be my own aëronaut.

SECOND ASCENT.—FROM PARIS TO COMPIÉGNE.

My friend M. Giffard had consented that I should have the sole management of his fine balloon for this ascent. I kept my word, and became my own aëronaut, for rage and disappointment had familiarized me with the regions of the air more than twenty consecutive ascents would have done.

Two young men, the brothers Chavoutier, accompanied me: they had never made an ascent before, and it was not without some difficulty that the permission of their parents was obtained. Both father and mother came to see them off, and I rather feared the result of the final adieu; so we started rapidly, like an arrow from the bow.

The elder brother was twenty-six years of age, and had already distinguished himself as a clever architect. The other, a boy of eighteen, began his balloon exploits in a very creditable manner; for he clambered up a vibrating rope ladder, more than twenty feet long, to untie "the garter of the balloon;" in other terms, to take away the cord that ties the neck. This manœuvre could be avoided in balloon ascents if the rope which terminates the neck were replaced by a very light safety ladder.

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The second ascent of the *Entreprenant* took place on Sunday, 22nd March, 1868, at a quarter past three in the afternoon, and in presence of numerous spectators. An easy manner of starting consists in overloading the car with ballast; then giving orders to let go, the passengers throw out a few sacks of ballast, and rise at once. If the ballast is dealt out gradually, they may rise as slowly as they like.

There was little wind, and the assembled spectators did not lose us from sight for twenty minutes, during which time we travelled slowly along in the direction of the Northern Railway.

My two companions were not allowed much time to admire the beauty of the landscape, the aspect of which would at once have driven away any sentiment of fear, had such occurred; for I was cruel enough to make them work for me without interruption, renewing the splices and altering the guide-rope, which I found was too long, and accordingly divided it into two portions, one 164 feet long, and the other 295 feet. Whilst this work was being accomplished, I noted carefully the indications of a Richard barometer, and a series of Baudin thermometers.

At the time of this ascent, simultaneous observations were made at La Villette, by M. Dollfus-Ausset, the famed Parisian ice-manufacturer, who had made balloon ascents before I had, and was kind enough to witness my first attempts. Doubtless he was anxious to see if one of my feet would get frostbitten again, as it was when I went up Mont Rosa with him.

At 4h. 42m. we soared over the forest of Ermenonville, at an altitude of about 2,300 feet, and heard several reports of guns. We learnt afterwards that a boar-hunt was going on there. A bag of ballast being emptied almost entirely at this moment, we rose to a height of more than 6,500 feet in less than seven minutes.

At 4h. 49m. we had got through the dense, but not very thick curtain of cloud, which, since early morning, had hidden the sun from our fellow-citizens below.

An aëronautic astronomer has a right to say of the sun what Mahomet said of the mountain; for he can go to it whenever it refuses to come to him: when once we passed through the dense layer of cloud, we might have imagined ourselves over the snowy summits of some of the Swiss mountains. The fixity of the snow-like peaks of vapour was really very striking. It was not difficult to imagine that they reposed on solid granite or basalt rock. They appeared perfectly still, yet all this mass of vapour was moving along with us in a northerly direction. Their tint was exceedingly brilliant and dazzling, whilst the sky above was of a tender azure blue, more

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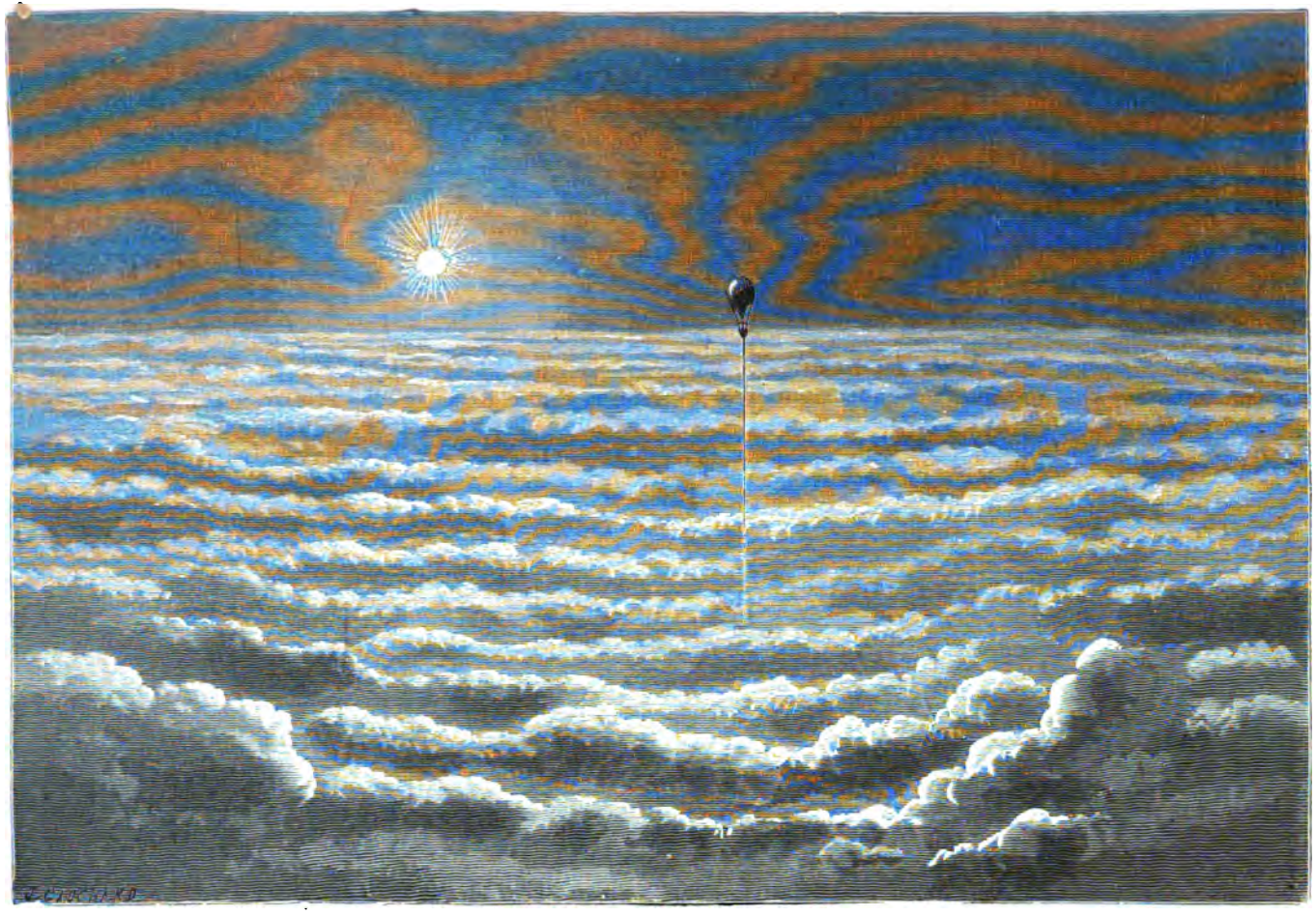

"THE FIXITY OF THE SNOW-LIKE PEAKS OF VAPOUR WAS REALLY VERY STRIKING."

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beautiful than when seen from the earth on the finest summer day, and without the slightest streak of white cloud; no delicate cirri clouds floated in the higher regions.

The sun was now sinking in the west, and appeared to me smaller than when seen from the earth's surface. The heat of its rays was very notable, for when we had reached the altitude of 7,874 feet it caused the mercury of a white-bulb thermometer to rise rapidly to 55·4° Fahr., whilst another thermometer kept in the shade of the car marked only 26°·6.

A strange phenomenon which we observed on this occasion deserves to be mentioned; but before alluding to it we cannot insist too strongly upon the peculiar character of the higher layer of the clouds below us. Judging from their shape, it would be thought that the atmosphere offered a certain amount of mechanical resistance to their onward motion, whilst their lower surface, on the contrary, offered immense excavations with denticulated edges.

It was into one of these depressions that the *Entreprenant* entered, at 4h. 46m., when we lost sight of the earth, which remained hidden from us during the remainder of the excursion.

The balloon soon began to swell out under the influence of the solar rays which heated and dilated the gas through the semi-transparent envelope.

At this moment we distinctly noticed a whitish smoke floating above our heads: it was perfectly visible, but not nearly so abundant as to cause any uneasiness. This young balloon, the *Entreprenant*, did not intend to smoke its pipe as the old *Giant* had formerly done; it is merely a cigarette this time.

Since then, however, we have asked many learned persons their opinion concerning this phenomenon. Some have mentioned ammonia; others have said nothing; none have replied to our queries in a satisfactory manner. We believe, at this moment, in the following explanation, which seems so simple as to be almost irresistible:—

Although the gas which fills the balloon is transparent at the moment of starting, it nevertheless contains a certain amount of moisture; in fact, shortly before arriving at the lower surface of the cloud layer, we have seen the interior of the balloon filled with vapour condensed into a kind of cloud by the coldness of the atmosphere. But as soon as the balloon has passed through this layer of cloud which hides the earth from our sight, it begins to get rid of this moisture both from the envelope and from the gas, and the latter becomes again transparent as before. Each time that the elder Chavoutier pulls the valve-rope, we can see the valve open, and two

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small crescents of light allow us to judge of the size of the opening; we can guess the moment when the caoutchouc springs outside will bring their valves together with tolerable force, and then we can hear a dry characteristic crack—a very curious species of small detonation.

But as it gets warmer and warmer the gas is uninterruptedly dilated, and makes its exit progressively by the orifice of the neck; for what goes out of the valve, carefully managed, is not sufficient to balance the increase of volume produced by the action of the solar rays. This warm gas that issues in thin streams into the cold external air (the temperature of which is below 32° Fahr.) is naturally subjected to the influence of this cold, and deposits its moisture as visible vapour. We have then just above our heads a manufactory of microscopic clouds; and these little clouds are soon dispersed into the surrounding atmosphere. But they may be of some use to us before they disappear entirely, for they mark the course of the balloon better than any flag could possibly do.

On the undulated surface of the white cloud layer, we see very distinctly the elegant shadow of the balloon. It follows us rather obliquely, for the sun is already far from the zenith, it being now past five o'clock. Our car comes out in black upon this brilliant white surface, together with our three heads and our two guide-ropes. If we had the proper apparatus, we might take a photograph of ourselves.

There is nothing difficult to explain in this; it is simply due to the fact that the balloon does not let light pass through it. A certain quantity of this light, the absence of which causes the black shadow on the snowy surface of cloud, is absorbed by the balloon. We might say that it is this portion which lights the pipe of the *Entreprenant*. In fact, it has produced the dilatation of the moist gas, and has been, consequently, the cause of that peculiar white smoke we noticed above. But besides this portion of light transformed into heat, there is another portion which has not passed into the balloon at all, and is not lost in the clouds. The portion of which we speak is reflected very symmetrically, as it might have been from a metallic mirror; for M. Giffard, who generally does things well, gave the balloon a new layer of varnish two or three days before we started. This reflected beam of light falls upon the layer of clouds above which we are sailing, but in its path it has taken a most singular form. I will endeavour to describe it, but will leave its explanation to those who are cleverer than I am—at least until I make my next ascent above the clouds.

In the centre of the strange reflected image a black point is very

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SHADOW AND LUMINOUS EFFECT AS SEEN FROM THE BALLOON

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distinctly seen: its tint is soft and graduated, and its diameter a quarter that of the moon. Around this disc we perceive a circle of rainbow colours, the diameter of which is about sixteen times greater; and around this first coloured circle is a second, the diameter of which is about double that of the first, and also tinted with the colours of the spectrum.

I made a rough sketch of the phenomenon, just sufficient to permit our friend M. Albert Tissandier to execute a chromolithograph of it.

The spectacle was certainly curious enough. On one side of us, the dark shadow of our aërostat; on the other, the marvellous reflection which travelled along with us over the white surface of cloud. Whilst I was sketching the optical phenomenon in question, we heard the vigorous notes of a horn, which reached us, I know not how, through the thick layer of clouds which separated us from the earth. It was probably the huntsmen at Ermenonville, who had just killed their boar and sounded their joyous fanfare. It was a quarter-past five in the evening.

I had promised my friend M. Giffard to come down about an hour after sunset; and, moreover, I had engaged myself to take with me, under my orders, some person who had been *at least once in a balloon.* The latter portion of the promise was rather embarrassing. . . . To satisfy my conscience, I had made the younger Chavoutier get into the balloon through the neck, whilst the aërostat was being inflated with common air. He had therefore been at least once *in a balloon,* though he had never quitted the ground; and he was in a position to see the numerous little holes in the envelope, the result of the preceding voyage from Paris to the forest of Ferrières.

In order to keep the first portion of my promise, I gave the necessary number of tugs at the valve-rope to enable me to quit the delightful spectacle of these higher regions about the time named. Without these conscientious scruples, which came upon me when soaring at an altitude of 7,900 feet, we should certainly have floated much longer in the atmosphere, and probably night would have overtaken us there.

The least experienced aëronaut, if he only preserves his presence of mind, can moderate with remarkable ease the impetuosity of the most vigorous balloon sailing in pure sunshine.

The accidents which have been related so often, with their dramatic surroundings, are all the results of a want of vigilance, of prolonged hesitation, or of an inexcusable surprise, the effect of emotion, causing forgetfulness of the most elementary of physical laws. In fact, the tension of the gas which fills the internal

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capacity of the aërostat is manifested by the respectable degree of rotundity taken by the silken or linen tissue. The balloon appears to swell itself with pride at the magnificent spectacle which it shows to its passengers.

Nothing is easier than to prevent your aërial courser running away with you, and carrying you off to those glacial heights where Zambeccari passed the night, and returned to the earth at dawn most frightfully frostbitten. You have only to raise your eyes in order to be certain that the open orifice of the neck is open, and will allow any excess of gas to issue easily.

Knowing by heart all the elementary principles of ballooning, I have got ready the grapnel, and arranged all the objects that it might be necessary to throw overboard, according to their respective value or their brittleness, so that they might be sacrificed one after the other in the proper order. I had even carried this arrangement as far as our luggage, in case the rapid motion of the barometer should give us cause for alarm.

The barometer is indeed the compass on which the eyes of an aëronaut must be constantly fixed, and his conduct must be governed by its smallest indications.

On descending, we soon find ourselves lost in the thick fog, which passes from us like a flash of dark lightning, and then we begin to recognize the surface of the earth below us, towards which the *Entreprenant* falls whilst it revolves rapidly on its axis. The needle of the aneroid moves with accelerated velocity, pointing to the fact that our descent is somewhat too rapid. I make a sign to the elder Chavoutier, whom I wish to train to this kind of work, and he throws out ballast by well-measured handfuls.

Beneath us lies a vast plain which has an hospitable appearance. I investigate it with my telescope; it shows none of the shoals which are known as houses, cottages, churches, castles, which are all equally detestable to an aëronaut who is descending from the air.

In an instant I believed that we should succeed in landing on these frank, well-ploughed fields, and I fondly imagine that we shall step out of our pleasure-boat as easily as from a carriage. But it is easy to see that a rather fresh breeze is likely to throw us upon the edge of the neighbouring forest. To avoid the trees, I must pull lustily at the valve without a moment's hesitation. I must accelerate the downward motion as much as the diameter of the valve will permit when open as wide as possible. But then we might come to the ground with a force I am as yet unacquainted with. Aërostation being completely ignored by pro-

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fessors of algebra, we have no formula which would enable me to determine the precise intensity of the shock which would be the consequence of my following out this first inspiration.

We have two guide-ropes which are very thick, and a stout anchor with a heavy rope attached; this would, on touching the ground, diminish our weight by a considerable number of pounds before our car struck the surface.

But I had promised to be prudent—to make an ascent *à la papa*. I hesitate, therefore; and, changing my plans, I make signs to the elder Chavoutier to continue to throw out the remainder of the ballast, and then the other objects in the order arranged. When the supply of sand is exhausted, he begins with the bottles. I wish, if possible, to soar over the forest. Supposing that we should get hooked on the road, the harm would be nought for us, and small enough for the balloon, if we are clever.

But it is too late to argue . . . . the grapnel has caught. We are floating at twenty or thirty yards from the ground—a mere nothing! . . . . We are landed, for we have taken root at the top of an oak-tree. In the course of ten minutes we have descended from a height of some 8,000 feet without a scratch or a bruise; so easy is the management of a balloon! . . . .

At this moment I was deceived by an optical illusion which might have had dangerous results, and I call the attention of my readers to it, in case they may ever be tempted to undertake the management of an aërostat. Let them never get out of the car until it is fairly landed upon the soil. Let them be perfectly sure that no solution of continuity exists between the car and the earth before they think of stepping out of it, for their eyes, accustomed to the immense proportions of things above the clouds, have lost their power of appreciating dimensions. Objects appear so small on the earth's surface during a descent, that great trees look like mere blades of grass. At this moment I believed we had descended upon heath bushes, and we were at the top of the high trees. I had actually got one leg out of the car, and was preparing to leap down! The two Chavoutiers bellow to the peasants with all the force their lungs are capable of. I tell them it is useless to shout in this way, for the balloon is seen from a great distance, and we shall soon have peasants enough. Effectively, in the course of a few moments, a human ants'-nest is moving under our feet.

Fortunately the voyage to Ferrières had given me a lesson, then considered involuntary and useless, but now looked upon as providential. I tell the elder Chavoutier to let himself slide down

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the long rope to which the grapnel is attached, and, as soon as he touches the ground, to obey all my orders punctually. He does obey them aëronautically; and now he is safely on the ground. But our tribulations are only beginning; for it happens that the balloon has fallen about half-way between two villages, situated one on each side of the wood; and each of them wishes to claim us as its own . . . . Our orders are not understood or misconstrued; we are pulled first to this side, then to that, over the tops of the trees. After being subjected for some minutes to these queer manœuvres, I send the younger Chavoutier down by the same road that his brother had taken, and remain alone in the car, endeavouring to pass the rope over the high branches.

The balloon begins to lose its ascensional power, and I begin to be fatigued with my work. I therefore order them to pull down the balloon in an opening in the wood. I jump out of the car—the balloon rises—and now I am able to establish some degree of order in the movements of the ninety peasants who are pulling at the ropes. After an hour of walking and groping about with the ropes, the balloon catches again in the branches of the oaks, which are exceedingly fine trees in this particular locality, and it has no longer the power to soar above them. If we do not mind what we are about, we shall have the entire machine firmly fixed at the top of a tree, whence it will be no easy job to recover it.

With the assistance of Charles Chavoutier, who makes splices like an old sailor, I fasten the guide-rope to the hoop of the balloon, so that the balloon flies up to the extent of this rope and leaves the car safely lodged in the midst of the branches.

No sooner was the difficult operation completed than I perceive a ditch, which, according to one of the natives, leads out of the wood to a plain. Having assured myself that such was really the case, I get all my men into line, and they pull the balloon away in spite of the wind. When they get it to the said plain, I ordered them to pull it down, and I endeavoured to open the valve by pressing on the springs, but a little gas only escapes. I take off the india-rubber from the valve, but no gas issues; it does not occur to me to apply a lancet to the envelope, so I fastened the balloon to a stump, thereby basely imitating what I saw done at Ferrières by my professional aëronaut!

As it was late we abandoned the *Entreprenant* and made for the nearest village, all of us together, when we soon filled the inn. I called for some wine, some beer, some cheese, and some ham, and every one helped himself to what he liked best. I offered a franc

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apiece to any of those who would like to touch money that had come down from the clouds, and several of my brave companions did me the honour to accept the present; I enlisted a few volunteers to assist me next morning, at daybreak, in taking in the balloon.

By daybreak next day I was not awake. The day was far advanced when we arrived on the little plain where we were to let the gas out of the balloon. I was not a little surprised to find that this work had been done in the meantime by the balloon itself; under the weight of its network it had gone down as flat as a crown-piece.

All night long the peasants had been running about with lighted torches, seeking for their children, who had wandered off towards the spot where we made our descent; all the children in the district had played truant, and run off towards the balloon; and when evening came on, these enthusiastic little fellows were far from their homes. Many of them, in order to get a better sight of us, had plunged into the wood, the forest of Compiègne, and found it difficult, no doubt, to tear themselves away from the spectacle presented by our aërostat. Thus we heard what sort of a night the balloon had passed. The wind, which had calmed down, as it often does, at sunset, rose again tempestuously at two o'clock in the morning. The balloon, till then, had remained quiet upon the grass, but at this moment it began to describe a wide circle around the stump to which it was attached, as a centre, and having the guide-rope for its radius. It had gone round the third of the circumference without accident, but at this point it met with a prickly bush, and a large hole was immediately torn in the envelope, so that the gas issued rapidly from it. Luckily no peasant was near with his torch at that moment; for the stream of carburetted hydrogen would have taken fire, and we might have had a repetition of what happened to an American aëronaut, whose balloon took fire by contact with the lighted pipe of one of the spectators, and nearly blew up about a hundred lookers-on.

To fold up the tissue was the affair of a moment only: but it remained for us to discover the car, the grapnel and its rope, *plus* a piece of cable about a hundred and thirty feet long. No one could tell us what had become of these; and we had to strike through the forest, following the track we had taken the previous evening, which we knew by the broken branches we had left behind us. To recover the car, we had to take a hatchet and cut a road for it through the thick broken branches. As for the anchor, it had stuck so fast to the top of one of the oak-trees, that we had to climb up to and cut away the branch. It fell to the ground

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from a height of twenty-seven yards, with a loud noise, and sunk in the earth, but this time we had no difficulty in uprooting it.

THIRD ASCENT.—FROM PARIS TO COURCELLES (LOIRET).

The brothers Chavoutier and I started on Monday, the 13th April, 1868, from the gasworks of La Villette, precisely at four o'clock, and soared off in a southerly direction. We were propelled by a north breeze, which, though not very violent, had frozen the persons who came to help us in our preparations. Thanks to the kindness of the manager of the gasworks, M. Cury, and his workmen, we soon got over the difficulty inherent to the inflation of a balloon in the open air when there is a wind blowing.

When scientific balloon ascents shall have become more general, it will be difficult to understand how a town like Paris could have remained so long without any aërostatic station, whence ascents could be made at any time and in any weather. For the more agitated the state of the air, the more curious and interesting is the course taken by the balloon.

The curious observations that we were able to make on this occasion would have escaped us entirely, had we been obliged to put off our journey till the morrow—had we, like so many other aeronauts, waited until the weather was calmer.

Simultaneous observations were made this time also by M. Dollfus Ausset, and the calculations revised by M. Collomb. We took up two spirit thermometers:[1] the spirit was coloured red, which makes the readings much easier, and the degrees were as nearly as possible three millimetres each in length, though the bulb was very narrow, so as to give the surrounding temperature immediately. In order to take every possible precaution, these thermometers were sunk into a flat piece of wood, and hung vertically to one of the ropes of the car. One of these instruments, manufactured with the greatest care by M. Baudin, was a wet-bulb thermometer, for the determination of the hygrometrical state of the atmosphere.

As during the whole of this ascent our temperature was below freezing-point, this wet-bulb thermometer was almost constantly surrounded by a thick layer of ice. The cold was, indeed, so intense, that when drops of water were sprinkled on to the bags of ballast they solidified into ice immediately. This phenomenon,

[1] No spirit thermometer is adapted to the determination of either the temperature or humidity of the air, and particularly in a balloon.—ED.

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which we observed several times in the most unmistakeable manner, is in contradiction to the notions generally held concerning the nature of clouds. In fact, we soared amidst vapours which had not the slightest crystalline appearance. The tint of the cloud which was in the state of vapour around us, though the temperature was 23° Fahr., was that of the light of a room with windows of ground glass.

None of us experienced that sensation which is usually produced by the contact of watery vapour with the skin. Moreover, though we were all three rather lightly clad, we did not experience a degree of cold at all corresponding to the external temperature as indicated by the instruments. Our sensations in this respect were not the least unpleasant until the balloon began to oscillate rather suddenly. When it rose, we felt the cold strike our shoulders; when it sank, we felt it at our feet.

The cold experienced at our feet was really painful, and I discovered accidentally that it was owing principally to a draught. When stooping to cover my feet in a rug, I found that the wicker-work of the car was torn along one of the narrow sides, and that there was an opening there at least a foot and a half long, through which the air passed abundantly.

Now, who knows, it occurred to us, whether the temperature of the car of an aërostat in motion is really that of the external air; whether it was as cold in the cloud-vapour that surrounded us as upon the bulbs of our thermometers; whether Barral and Bixio, Gay-Lussac and Glaisher, did not create, by their motion through the atmosphere, the low temperatures which they observed when they rose rapidly into the higher regions of the air? A careful discussion of the movement of our aërostat, and of the temperatures observed, might, perhaps, lead to some unexpected data in this respect. However that may be, and whatever explanation we may be forced to adopt to account for the strange fact, we believe that we were the first to observe, in an unmistakeable and continuous manner, so low a temperature in the midst of watery vapour, not unlike that which escapes from the boiler of a steam-engine.

During this ascent the clouds presented a most singular aspect. They were accurately divided into three distinct layers, the lowest of which was composed of small rounded cumuli, perfectly visible, and floating at a height of between 1,600 and 2,000 feet, like the little storm-clouds which we see in summer just below the dense cloud charged with electricity. The edges of these small rounded clouds were very sharp and well-defined. They were projected

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on to the fields below like so much white vapour. To any one visiting these regions for the first time, they might be mistaken for smoke coming out of the ground.

Above them was an oily layer of cloud, opaque and homogeneous, and so thick that during the whole of the day it did not allow a single ray of sunshine to filter through it. The external surface of this cloud-layer was splendidly flat, and of a marvellous snow-like tint. It differed from that seen in our previous ascent in having no protuberances, hollows, or valleys of any kind.

Above our heads the firmament was covered with a layer of vapory cotton-like clouds, rising like an immense cone more than a thousand yards high. Through the openings in the clouds we saw the blue colour of the sky beyond, and towards the west a silvery tint of unrivalled delicacy. The wind, which carried us along without our perceiving it, brought to our ears the sounds to the north of us. We heard the barking of dogs, reports of musketry, and even the cackling of chickens, so sonorous was the surrounding atmosphere.

We were not more than 300 feet above the dense level cloud-layer, for our guide-rope plunged into it by its extremity, and was lost in it as in an opaque ocean of ivory and alabaster. Its smooth surface reflected the sound of our voices very distinctly, and an echo appeared to rise from beneath the car whenever we made the experiment.

Soon we witnessed a majestic phenomenon, which I should have taken for an optical illusion, had not Tissandier and myself succeeded in explaining it in our ascent from the Conservatoire des Arts et Métiers.

It was not without the utmost astonishment that we saw an immense ring of clouds, the centre of which corresponded with the projection of our car, opening out beneath us as though it were the work of some invisible hand. Its radius appeared to be four or five times the length of our guide-rope. The vertical sides duly projected produced the effect of a dark halo of 46 degrees reversed upon the higher surface of the clouds. Above our heads the masses of vapour hollowed themselves out into a gigantic vault, rendered brilliantly luminous by the reflection of the sun's rays. It was like a vast tunnel of compact cloud through which we were sailing along in silence.

The lower portion, as a whole, was like an immense circular basin, such as that in the Tuileries, but twenty times as wide and ten times as deep. The background of this gigantic excavation was perfectly flat. The edges were like a lining of black rock, especially towards

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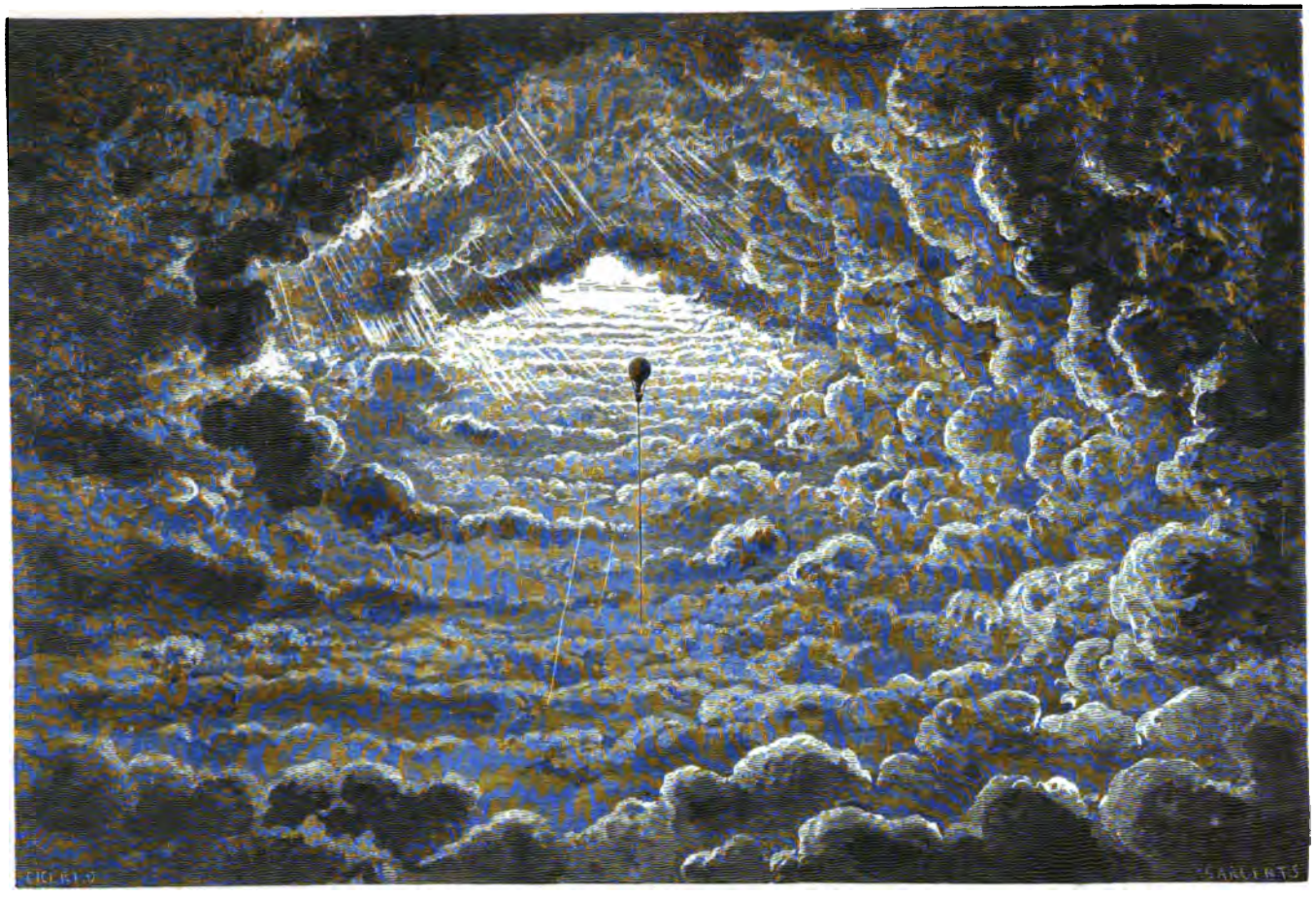

EFFECT PRODUCED BY A VAULT OF CLOUDS.

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UNIV. OF MICH.

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the east; but the white snow-like layer which formed the bottom of the basin, like a plain, covered them in several places, so that the black rock-like protuberances only appeared here and there to break the monotonous whiteness of the scene.

Unfortunately our ballast was expended, and we were not able to contemplate this magnificent spectacle for any length of time. Soon after this the first, and then the second rope touched the ground; we were over a poor, thinly-covered pasture-ground. The valve was opened, and soon the grapnel struck into the soil.

We only experienced one bump, which was scarcely appreciable, thanks to the splendid india-rubber ring (invented by M. Giffard) attached to the hoop of the balloon, and to the grapnel rope. This acts as a spring and deadens the shock. The anchor was not fixed, however, in the friable soil, but scored it up splendidly for some distance, like a plough driven with a speed of some twelve to fifteen miles an hour, or as the water is ploughed up by the power of a powerful steam-tug.

The balloon bends over coquettishly in the direction of the river, which is too far distant, however, to cause us any uneasiness. As the gas issues from it the wind enters, and we hear the sides clapping like the sails of a ship against the rigging. The elder Chavoutier has still hold of the valve-rope, and our aërostat comes gradually down. It arrives upon the ground at the same moment that we do, and rolls itself about on the grass like a spoilt child, then suddenly rises up again, and we of course follow.

Two or three more moderate shocks follow, during which the valve-rope escapes from the hands of our companion. It is easily got back again; but in future, to avoid this circumstance, we shall have it attached to the hoop.

A man dressed in a white smock-frock approaches, and we request him to hang on to one of the ropes. . . . . We spring to the ground one after the other, and inquire where we are. The little river above mentioned turns out to be the Lima, a branch of the Essonne, which itself falls into the Seine at Corbeil. The nearest village is Courcelles, a league from Beaune-la-Rollande (Loiret), and sixty-four miles from Paris by railway.

When the brothers Chavoutier and myself leaped out of the basket, we found ourselves surrounded by a crowd of country-folks, who had run to meet us from all sides. The next day, it appeared, there was to be a fête in the village near which we had descended. The mayor of the place had been presented with the cross of the Legion of Honour,—for distinguished municipal services, said the

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Moniteur,—and all the rural population of the district had assembled to congratulate him.

Suddenly I felt a hand upon my shoulder, and, turning round, perceived standing near me a *garde-champêtre*, or village police-officer, and behind him two dogged-looking peasants. It is evidently a Rabelaisian quarter of an hour, thought I, that is coming upon us in the shape of injured proprietors!

An indemnification was claimed for the damage done in the field by the balloon, and rent for the spot now occupied by the aërostat! The air of the clouds had rendered me generous, and my first impulse was to open my purse.

"Say, my friends," I began, "how much will satisfy you?" "Ah, sir!" said the sourer-looking of the two; "it is dusk now, and we cannot see the amount of damage you have done to the saffron."

I was not aware that we had come down into a saffron field, or rather I believe it was simply a poor description of pasture-ground. The peasant continued in very crude French to inform us that he should visit the field with an expert or referee at the break of day, and take down accurately the amount of damage done. Whereupon I turned my back to him.

As it was now getting dark, it was necessary to return to the village. A waggon had been sent for, the balloon was installed triumphantly thereon, and we were escorted back by two or three hundred people.

Next morning at nine o'clock I heard a knock at my door. It was the said *garde-champêtre*, for the second time of asking. He informed me that the malcontents were below. I went down to them in rather a bad humour, and found four instead of two. The two new ones were those through whose field the anchor had passed. The inquiry had been conducted by a sworn surveyor, a shocking scoundrel, and the damage was set down at ninety francs *plus* one franc for his fee.

"Will you accept forty francs?" I demanded of the plaintiff. "You are trying to impose upon me, sir; you know full well there is no harm done. Take my offer at once, or I give you the word of an aëronaut, you will not get a single sou." Thereupon the *garde-champêtre* was about to give us a little of his official eloquence, but I begged him to go about his business, and I then cut the discussion short with the four injured individuals.

When they were gone, the other peasants in the room informed me that three of these individuals were old rascals who wished to impose upon me; that, after all, the saffron would grow up again.

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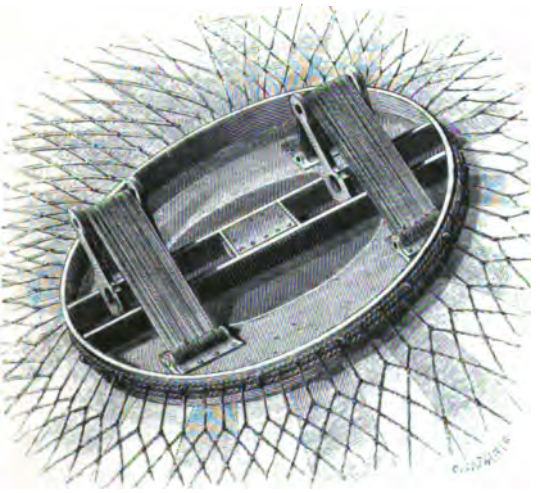
One of the complainers wished to accept my offer: I learnt that he was a ruined man, and that to make matters worse, if possible, he had just lost his son, taken from him at the last ballot. I could not resist the desire of acting the part of St. Vincent de Paul, so I had him called back. He claimed fourteen francs as his share of the damage, which I paid in my generosity, together with a glass of wine and a shake of the hand into the bargain.

Whilst I was thus engaged I heard a great uproar outside in the courtyard, where the balloon was being packed up. It was caused by the elder Chavoutier, who was holding a lad by the ear, bringing his head into the room towards me, whilst the body followed in a series of comical contortions. The young culprit had been discovered in a barn, with a knife and a piece of the stuff of our balloon in his hands. It was one of the choral children of M. le Curé. Divine goodness! To cut up the balloon of my friend Giffard and distribute it about as relics, would indeed be a curious notion! Nor could I help laughing at the idea as I ordered the prisoner to be set at liberty; his departure from the room was, nevertheless, somewhat accelerated by a stout kick from one of the peasants.

Some days later, when at Paris, I received a letter from an attorney, offering his services to defend the plaint which was about to be brought against me by one of the above-mentioned saffron growers. I hastened *not* to reply to it, and so the matter remains to this day.



THE VALVE OF THE "ENTREPRENANT" BALLOON.

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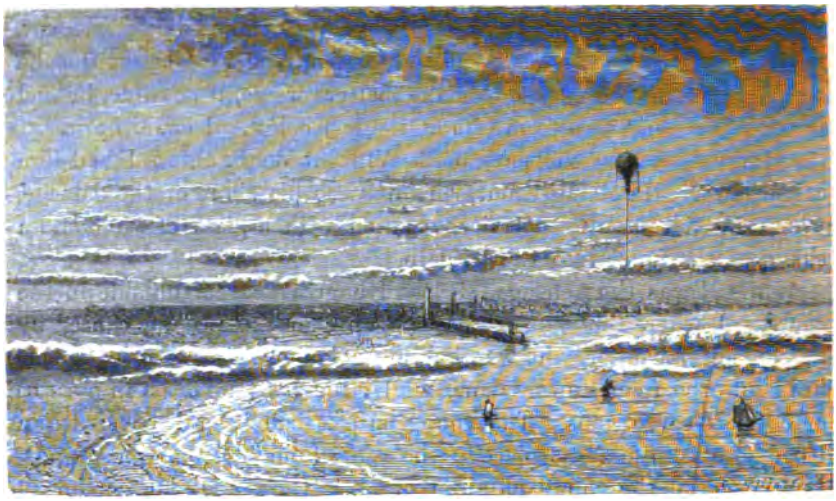

CALAIS AS SEEN THROUGH THE CLOUDS FROM THE BALLOON.

CHAPTER IV.

MY DÉBUT IN AËROSTATION.—VOYAGE ABOVE THE NORTH SEA.

(G. TISSANDIER.)

THE illustrious author of "The Harmonies of Nature" confesses that he never looked at the clouds without a profound emotion, and that he took the greatest pleasure in contemplating the thousand modifications of form undergone by those vast masses of vapour, "so like groups of mountains rolling one after the other along the azure sky."

Who could, indeed, remain unmoved before the fine spectacle presented to us by the limpid atmosphere so capriciously intersected with white vapour, and notice the magnitude of its extent, without experiencing a desire to become acquainted with the mysteries hidden in its bosom? The calm zephyr or the tempest blast, the mild breeze or the terrible cyclone, offer admirable pictures to the true lover of Nature; and the air, like the ocean, proves a source of invincible attraction to the mind.

Whatever may be said by certain pedantic physicists who wish to ignore balloons, science has much to learn from these aërial voyages. "It would require a volume," says Lavoisier, "to describe all the advantages that aërostats can bestow upon society at large;" and Arago also took the greatest interest in balloon ascents. Most of our

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learned men understand the scientific service that may be done by these aërial skiffs, which may truly be termed "floating observatories," carrying the philosopher into the midst of the atmosphere, and placing him in immediate contact with some of the grandest phenomena of Nature, enabling him, perhaps, to discover the causes and mechanism of aërial currents.

All honour to the mariner of the atmosphere who shall discover the *Gulf Stream* of the air, and shall lay down the foundation of a true science of meteorology! In exploring these aërial regions, in sailing backwards and forwards through this moveable ocean, though he may not discover, as Christopher Columbus did, a vast new continent, he may nevertheless enrich the book of modern science with numerous discoveries.

But besides the scientific interest attached to these excursions, are we not attracted also by the odd manner of travelling and the charm of meeting with novel scenes? If a tourist can clamber painfully into the glaciers of the Alps in search of new sensations, could he not do better in carrying his yearning after novelty into the regions of the clouds? As for myself, I had never seen a balloon pass overhead without longing to make an excursion into the air! But, alas! there is a vast distance between the desire and its accomplishment.

It was the *Giant* that drew me definitively into what I may term my aërial calling. I shall never forget the ascent of that fine aërostat from the Champ de Mars, accompanied by the little *Imperial*. I have still before my eyes those two balloons, the one so large, the other so small, awaiting the signal to rise into the air and soar through the clouds like an eagle. I still see the *Giant* rising majestically as the signal is given: a cloud of sand falls from the wicker-work car, and the balloon is soon lost to sight in a thick curtain of vapour. Around me, arms are uplifted on every side, shouts pierce the air, hearts beat fast, and every one returns home thinking of the aëronauts.

How many days passed since the glory of M. Nadar and the moment when, wet to the skin by the rain, I was about to take my place in the car of the *Neptune!*

It was a great red placard that awakened all my aërostatic tendencies, quieted after a thousand vain attempts to realize them. It was the 12th of August, 1868, I was at Calais, when I saw the said announcement of an ascent (on the occasion of the Emperor's Fête on the 15th) fixed to take place on Sunday, the 16th. This voyage was to be undertaken by an aëronaut, M. J. Duruof, of whom

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I had never before heard. On the same day some regattas were announced, but they had little interest for me. Not so the balloon ascent, which I continued to think about all day.

Next morning I made my way early to the Hôtel de Dunkerque and inquired for M. Duruof, when I was ushered into the presence of a young man, the captain of the said expedition. After a quarter of an hour's conversation we were the best friends in the world, and he was kind enough to offer me a place in the car of his balloon, and thus enable me to make my first ascent.

I was transported with joy on leaving him; but how great was my stupefaction when I found that my friends heard of this intended ascent with marks of the most profound indifference, and even regretted to see me engaged in such a miserable adventure. They informed me that Duruof had already attempted to make an ascent at Calais, and that he had purposely caused his balloon to burst just upon starting; that he would not start this time either; and for the first, but not the last time, I perceived that certain people were prejudiced.

Some members of my family were also at Calais, and manifested great uneasiness, reminding me of the danger of an ascent on the seacoast between the English Channel and the Northern Ocean. "This part of the world," they said, "is particularly fatal to balloons and aëronauts. Pilâtre de Rozier lost his life not far from here, and Deschamps was nearly killed on the same coast; the wind is always violent and uncertain along the shore, and it is pure folly on the part of any one to undertake such an adventure."

Nevertheless I held firm to my resolution, and passed the day of the 15th in assisting M. Duruof to discover and mend the small holes in the tissue of our balloon. In the next place I ran to the Humane Society's office to get some life-belts and floaters; for I did not forget that our excursion lay over the seacoast, not far from the "great basin," as my friend expressed it.

At night I dreamt the most extraordinary dreams about balloons. I saw one burst just as it was starting, and every one turning to laugh at and ridicule me. In another, I find myself soaring rapidly into the air, and a little later precipitated violently into the waves below; in fact, a thousand fantastic images floated in my brain, when I felt myself shaken by a vigorous hand.

"You must get up, sir; it is half-past five, and you told me to be sure not to let you sleep any longer."

It was the waiter of the hotel, calling me back to reality. I rose hastily, and proceeded to the Place d'Armes.

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GASTON TISSANDIER.

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Duruof and his assistant, Barret, were already there; the *Neptune* lay miserably along the ground, and the rain was falling in torrents. It was a sad, disheartening spectacle, and filled my mind with confused ideas; for it might be impossible to inflate the balloon. How could I imagine, indeed, that this muddy tissue lying at our feet would soon carry us up into the clouds?

"Do you think," I asked anxiously of Duruof, "that it will be possible to inflate the balloon in such weather as this?"

The captain of the *Neptune* fixed his eyes upon me as he replied: "I see that you do not know me. I was unfortunate in this very spot last time: the wind prevented our departure; but I have a revenge to take, and I do not fear the rain; we will make our ascent whatever may happen."

By this time the gaspipe was placed in contact with the *Neptune*, and what with lifting up the valve, widening out the net, and moving the ballast-bags, the head of the balloon began to rise from the ground. The passers-by stopped to look on, and soon the smile of incredulity and mockery was replaced by marks of serious attention. At twelve o'clock the rain ceased, and the aërostat stood majestically up in the Place d'Armes, in presence of the bust of the Duc de Guise, which seemed to look down upon the operations with astonishment.

The crowd increased rapidly as Duruof attached the car to the ropes of the hoop. The soldiers who lent a hand at the ropes were now and then pulled off their feet and suspended like bunches of grapes in the air, so impatient did the balloon seem to soar up above. At this moment an English gentleman approached and examined the tissue of the balloon with great care; then turned his attention to the ropes of the car and all the accessories, which he likewise scrutinized most minutely. The sight of this proceeding terrified me not a little. What if the stranger were to offer a large sum of money to Duruof to take him up? I should lose my place, and my purse could certainly not compete with his! It was indeed an anxious moment.

A friend approached me just then, and said: "You appear uneasy; are you afraid?"

"Yes," I replied; "I am very much afraid—of being obliged to remain on the ground!"

A small trial balloon was then sent up, and its course followed by a thousand eyes. In one bound it flew against the bell-tower of the town-house, then rose again and made directly for the Northern Ocean. I turn to look at Duruof. He is still calm and resolute.

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As for the Englishman, he appears to have evaporated. Perhaps the prospect of a descent into the waves had warned him off.

At four o'clock, Duruof, Barret, and myself get into the car. The men at the ropes, in obedience to the orders of the captain, draw us along to the angle of the square which is furthest from the tower of the town-house, and the "excellent music" mentioned on the placards begins to make its melodious chords heard. . . . .

The signal "let go" is given; and here we are, soaring in space amidst the hurrahs of the astonished crowd of spectators.

What joy for the beginner who feels himself for the first time carried away by the breeze! What emotions he experiences when he sees the earth fly away beneath him, the horizon extend itself on all sides, whilst he contemplates the double panorama of the earth and the ocean!

When I saw a thousand vapours rising afar off from the bosom of the waves, and following each other like a legion of spirits, I could well imagine such clouds to be animated beings, and involuntarily recalled the celebrated comedy of Aristophanes, in which the clouds exclaim—"Let us show for some minutes to the sight of man our face, which changes every instant, and which, nevertheless, will last to all eternity! Let us go forth trembling from the bosom of our father Oceanus! Let us scale without loss of breath the snowy summits of the mountains! Let us remain on these heights whence we can see no longer our image reflected in the azure mirror of the seas." . . . .

How astonishing to find oneself so still in the wicker basket, floating in the midst of space, without feeling the slightest friction or the slightest motion!

In one bound the *Neptune* rises to the crest of the clouds, which we pass through rapidly; we are already near 4,000 feet high, and the sea foams beneath our car. Duruof looks at the compass. "We are making for the coast of England," he exclaims. But our joy at this announcement is of short duration. By noticing more carefully the motion of the balloon, we find that our direction lies north-east; it is towards the middle of the Northern Ocean that the wind is carrying us.

I turn again to Duruof. His eyes are animated, and he appears plunged in thought.

"What are we doing?" he murmurs, with visible emotion. "I said I would follow you anywhere," I replied calmly. "Well! let happen what may, we cannot stop. The Calais people won't say I'm a coward this time!" I could not help thinking of Deschamps, the

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poor aëronaut of whom I had heard, who was placed in circumstances very similar to ours at Calais itself. To prevent himself soaring away over the sea, he had opened the valve of his balloon and fallen heavily on to the shore, when he was nearly killed.

But the splendid panorama which unrolls itself before our eyes is sufficient to dispel all sense of danger, and we scarcely dream of the rapidity with which we are being carried out to sea.

To our left we perceive the town of Calais, like a city in miniature placed upon a lilliputian shore; we distinctly see the jetties of the port, and a cloud of microscopic spectators running along them like a family of ants. At our feet spreads the transparent sea, like a vast field of emerald, brilliantly lit up by the solar rays. The entire scene is separated from us by a legion of fleecy clouds sailing along in a horizontal plane, and apparently formed at one side of our horizon to be dispersed at the other. Looking upwards towards the sky we see other violet-coloured clouds, which appear to be suspended at a great height in the air, for they are at an immense distance from us, and we are 5,900 feet high. The temperature is 59°·6 Fahr., and we feel very comfortable in our car, plunged in the undisturbed serenity of cloudland.

I shall never forget this remarkable procession of clouds sailing along with great rapidity below the car of our balloon. They were like a quantity of flocks of wool drawn along by some invisible hand; they arose in the distance where the sky touched the sea, so that their whitish cumuli appeared to issue from the surface of the ocean. How could fear, or any such emotion, find place in our thoughts when such novel and marvellous scenes were before us?

I had scarcely taken my eyes from the clouds when we perceived a very unexpected phenomenon of mirage, which added to our astonishment.

We turned to look for the coast of England, but it was hidden by an immense veil of leaden-coloured cloud. Raising our eyes to discover where this cloud-wall terminated, we perceived above it a greenish layer like that of the surface of the sea, and soon we descried upon it a little black point, the size of a walnut-shell. Fixing our eyes upon it intently, this little moving spot turned out to be a ship sailing upside down upon an ocean in the sky. In a few moments a steamer made its appearance—it was the image of the boat from Calais to Dover, and by the aid of my telescope I could distinguish the smoke coming out of the funnel. Then two or three other vessels came upon the scene, and added to the

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wonders of this magic sea, projected into the air by a fantastic effect of mirage.

The jetty at Calais is no larger than a lucifer match, but I can still see the crowd of spectators upon it and those upon the shore, and I remember that I have friends and relatives anxiously watching our course. This causes me to reflect upon the unfortunate direction our balloon is taking. The lighthouse of Gravelines can be faintly distinguished already. Dunkerque is not far distant. As we sail over the immense Northern Ocean I feel that our balloon is a mere grain of sand which the waves would devour in a few instants!

But we now cast our eyes towards the lower clouds, and, to our utter astonishment, find that they are all moving towards Calais! Whilst we, at a height of 5,249 feet, are sailing along towards the north-east, those cumuli which we passed through at the height of 1,969 feet are travelling in an opposite direction, towards the south-west. It is therefore evident that if we allow the balloon to sink into this layer of air below, it will carry us over Calais again, along with those welcome clouds which act as guides towards us, and point out the way to reach the land.

"We can continue our excursion over the sea," said Duruof; "we can return to shore again whenever we like."

Thus we allowed ourselves to be carried away, without any apprehension, by the higher breeze; for we knew that nearer the surface of the water the wind was blowing towards the land.

Whilst we were indulging in the idea of an easy return to the shore, we saw the crowd of spectators viewing us anxiously from the coast around Calais.

Some old sailors, we were afterwards told, were looking at us through their spy-glasses. "Poor fools!" they exclaimed, "they are lost; what did they want up there? *Qu'allaient-ils faire dans cette galère!*"

We had left the port about an hour, and had accomplished seven leagues over the sea, when we began to think that our excursion had lasted long enough. We ceased to throw out any more ballast, and the balloon soon sank towards the ocean's surface. We passed a second time through the clouds, and came within 400 yards of the water. It is now five o'clock.

We see some boats coming to our rescue, and one of them tacks straight towards us. However, we soon perceive that we shall not require their assistance.

The lower breeze wafts us along rapidly above the waves, and

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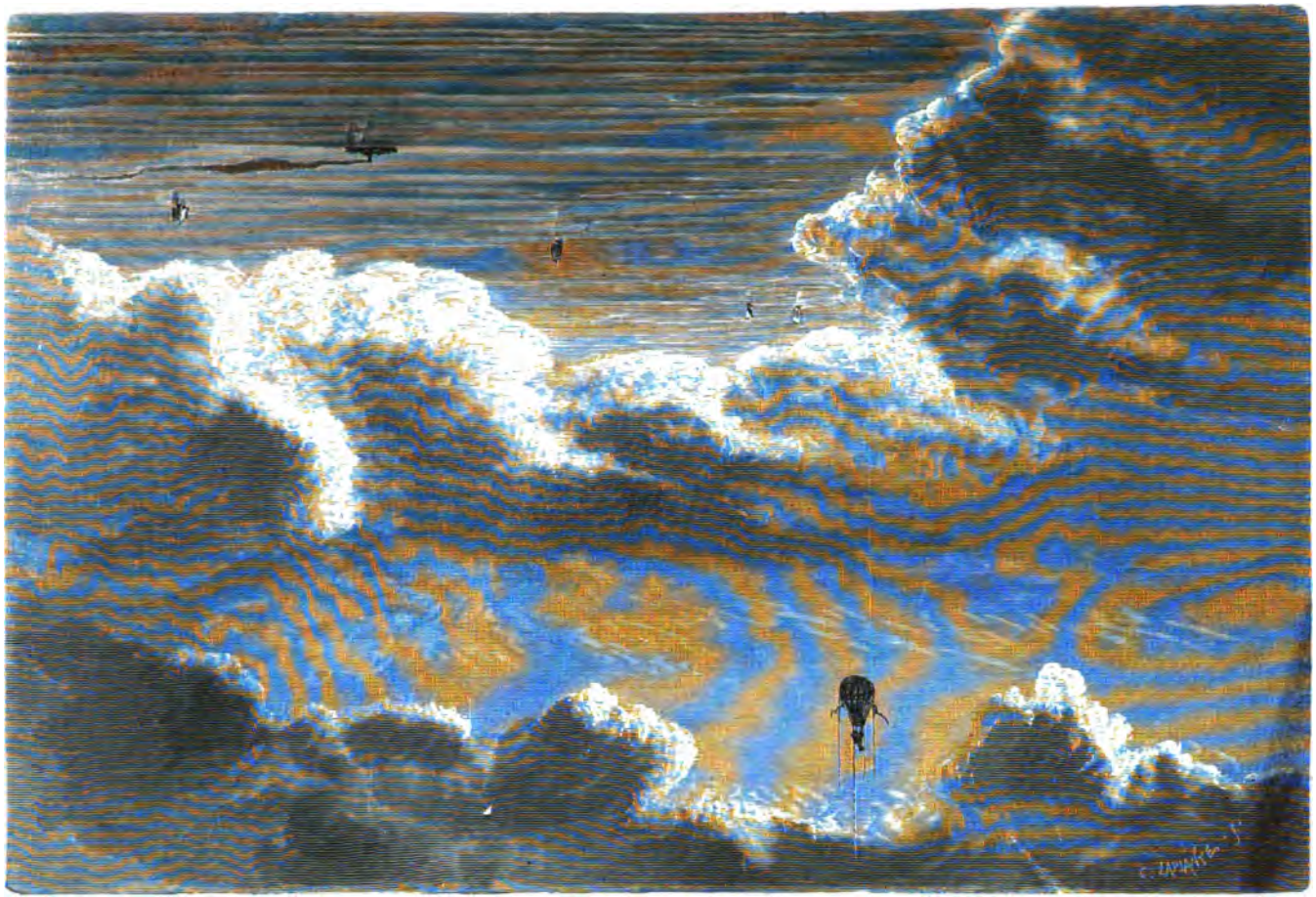

MIRAGE IN THE SKY, AS SEEN FROM THE BALLOON.

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Calais gets larger and larger as we approach it: the wind seems to be bringing us back to the spot whence we started.

In about a quarter of an hour we gain the shore, and the *Neptune* soars over Calais amidst the enthusiastic applause of the people assembled! Whilst passing over the jetty I looked down at the spectators, and in the crowd I recognize my brother, who sees me also and waves his hand. Is it a strange coincidence, or a sympathetic influence, that causes my glance to meet his among those of ten thousand others? The Place d'Armes is again beneath us, but quite deserted, for every one is on the shore. There is the bust of the Duc de Guise once more, the only figure that does not raise its head towards us!

The crew of the *Neptune* cannot contain itself for joy. We all shake hands, and congratulate ourselves on having made a trip over the ocean without experiencing the slightest effects of sea-sickness. A handful of ballast thrown out causes us to ascend a little, and now we can admire the country which extends below. I notice the guide-rope which hangs from our car.

"Take care, Duruof," I exclaim; "the end of our rope seemed to touch the ground."

"Are you mad?" he replies; "we are more than 4,500 feet above the earth."

Now, our guide-rope was only 430 feet long; and I fancied I saw the extremity of it touching the ground; my eyes had actually deceived me to the extent of more than 4,000 feet! This is a common error to which those who are not accustomed to see things from a great height in the air are liable.

A little further on I notice some white points moving about slowly in a field, and seek in vain to discover what they are. By looking at them through the telescope I find they are cows grazing peacefully below, and little thinking that they form the object of a telescopic investigation from the skies.

At 5h. 35m. we come nearer to the earth, and our guide-rope runs along a field, overturning some small stacks of hay. A few peasants run towards us, and we ask where we are.

"On the road to Boulogne," they reply.

One of them endeavours to catch at the rope, but as we do not wish to come down Duruof tells me to throw out some ballast. In my inexperience I empty an entire sack, or nearly so, and the consequence is that we rise rapidly to a height of 5,900 feet, and find ourselves suddenly enveloped in clouds so dense and so opaque that we can no longer see the balloon, nor scarcely recognize each

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other. We appear to be buoyed up by the thick fog around us, which produces in my mind a series of vague and strange ideas. It seems like a dream—our view is arrested suddenly by the dense heavy mist in which the *Neptune* is completely hidden and our wicker car appears quite still. Reflection alone enables us to feel assured that we are some 6,500 feet above the level of human passions!

Since early morning, when we had worked hard at the inflation of the balloon, nothing had passed our lips. We were now hungry; so, opening one of the boxes in the car, I took out a bottle of wine and a chicken, which we ate with a good appetite whilst enveloped in the mist. I threw one of the bones overboard; but Duruof remarked that this was an act of imprudence, for no ballast should be thrown out without orders. I believed he was joking, but on consulting the barometer I was bound to admit the fact upon the clearest evidence. The bone had certainly caused us to rise from twenty to thirty yards, so delicately is the balloon equipoised in the air.

The clouds seem to be getting thinner; they still hide the earth from sight: we see the sun disappear below the western horizon, red as a disc of fire. A thousand brilliant rays illuminate the sky, and throw our shadow upon the distant valley of clouds which spread around us. They are formed of immense white heaps, no longer like light vapour, but rather mountains of snow. Dark shades lie among their mysterious ravines, and give an imposing aspect to the vast undulations of this fairy world.

Where can we be now? Has the wind carried us on towards the interior, or driven us a second time out to sea? It is seven o'clock.

Our companion Barret draws our attention to a kind of vague murmur which he hears below the clouds. A continuous and melodious sound reaches our ears, but it is both menacing and terrible. . . . . Can it be the ocean?

By allowing a little gas to escape, we soon sink through the clouds, and we perceive below, not the earth and green country, but an immense expanse of sea.

The sun is about to sink into the waves, which he illuminates with a thousand splendid tints, and Night is about to spread her mantle over the dark ocean. . . . How imprudent we have been! Are we not trying fortune too hard, and soliciting adversity by coming a second time over the ocean depths from which we have

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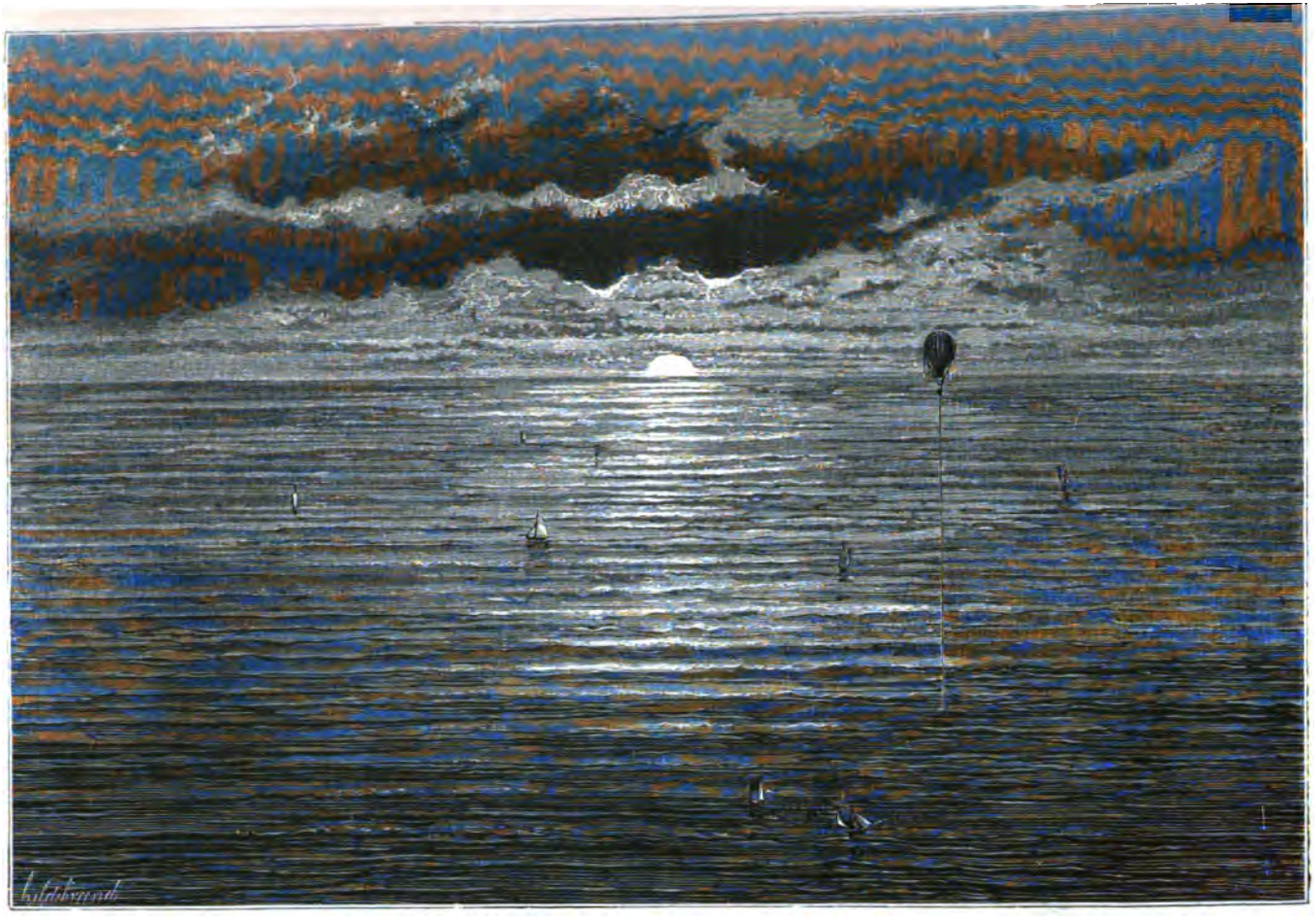

SUNSET WHILST THE BALLOON IS AT SEA.

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escaped so miraculously just before? But it is useless to philosophize; we must act. . . . The powerful breeze that reigns along the ground carries us in towards the shore, and it has already saved us once! Soon we see a cape, which spreads itself out before us like a narrow promontory, and becomes wider as we near it. But will the *Neptune* reach its side, or will it rush past its extreme point and carry us on over the vast ocean?

Night is falling fast, the sky is overcast, and every second of hesitation may now prove dangerous to us. We were all three silent during this solemn moment, and kept our eyes fixed upon the lighthouse which rises on the point of the cape. I shall never forget those few moments of intense anxiety; for all depended upon our reaching the side of the cape, and, in spite of all my efforts, the idea of a tragical death rose vividly to my thoughts. The sun never appeared so red to me as it did whilst it sank into the watery grave that appeared prepared for us. Then my eyes would turn towards the shore, and imagination called up the figures of many dear friends with outspread arms to receive us. Then again our glances would wander over the ocean surface, where a few boats rolled and heaved upon the foaming waves. The whole panorama imprinted itself vividly upon my mind, and the monotonous sound of the rolling waves filled us with sad presentiments!

Suddenly Duruof allows a cry of joy to escape from his lips; and this time there can be no doubt whatever that the wind is really carrying us upon the coast. The moment of action has arrived, and courage animates our crew! Hope buoys us up and puts an end to our dreary reflections. Duruof pulls the valve-rope, and the balloon soon sails nearly upon the surface of the waves. At the same moment Barret throws the grapnel out, and as soon as we reach the shore I let go the anchor also. It soon strikes in a sand-hill, and the *Neptune* rolls over on its side with the rapidity of lightning. A flock of sheep grazing at the summit of the grassy hillock fly off in alarm, whilst the young peasants who are tending them are likewise seized with fright, and tumble one over the other in their terror.

Fortunately some men came up to help us, among whom is the brave Maillard, the sub-guardian of the Gris-Nez lighthouse, who has already done good service on the coast. He imagines that we have heard of him, and his feet are bleeding from the effects of his hasty descent along the rocks. He seizes upon the rope which Duruof throws to him, and two fishermen imitate his generous enthusiasm. In

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spite of this help the *Neptune* still bounds upwards, and is ready, with the stiff breeze that blows, to carry us and the men over the hill into the sea. Duruof perceives the danger, pulls lustily at the valve-rope, and brings down the balloon upon our heads as the gas escapes.

Our veteran companion, who has helped us bravely out of our difficulties, tells us that he saw us far away over the briny deep, like a little black pear above the horizon: he watched us through his telescope, and could not help believing at first that it was a mere child's balloon he saw; but when he noticed our movements in the car below he knew he was mistaken, and imagined that, like Blanchard and Green, we had crossed over the Straits of Dover. In spite of our safe arrival, the lion-hearted Maillard declared that although he would not mind risking his life upon a safety raft upon the wide Atlantic Ocean, he would never ascend in a balloon, were it the finest aërostat ever constructed.

He also told us that on the other side of the hills, a few hundred yards from this *mont-aigu* where we had landed, rises the tomb of the first aëronaut—that of the illustrious Pilâtre de Rozier—who was smashed to pieces on the rocks here about a century ago.

The next day we visited this celebrated tomb, and I shall never forget the humble stone that marks the spot where this most courageous and learned man met so premature a death, carried away by his enthusiasm for scientific research and love of adventure.

Night came on whilst we undid the network of the *Neptune*, and folded up its now inert tissue. A custom-house officer approached whilst we were thus occupied, and demanded our passports. He carefully examined the car of the balloon, to see if anything had been smuggled, and would doubtless have gone into the interior of the balloon itself if he could have done so, in the hopes of discovering some forbidden fruit hidden beneath its folds.

I left Duruof and the fishermen to finish the work whilst I ran to the nearest telegraph station and sent off a few words to Calais, to ease the minds of my relatives and friends by informing them of our safe arrival. I had only an indifferent lamp to guide my steps over the rocks, and I should have broken my neck on more than one occasion had it not been for the good-nature of a fisherman who accompanied me and pointed out the dangerous spots. I sent off the telegram and received an answer; then, rejoining my companions and the worthy sailors, we all made for the village of Audinghem, across the downs.

When we were comfortably installed at the little inn there, we felt very glad at having returned safely to the earth again, and listened

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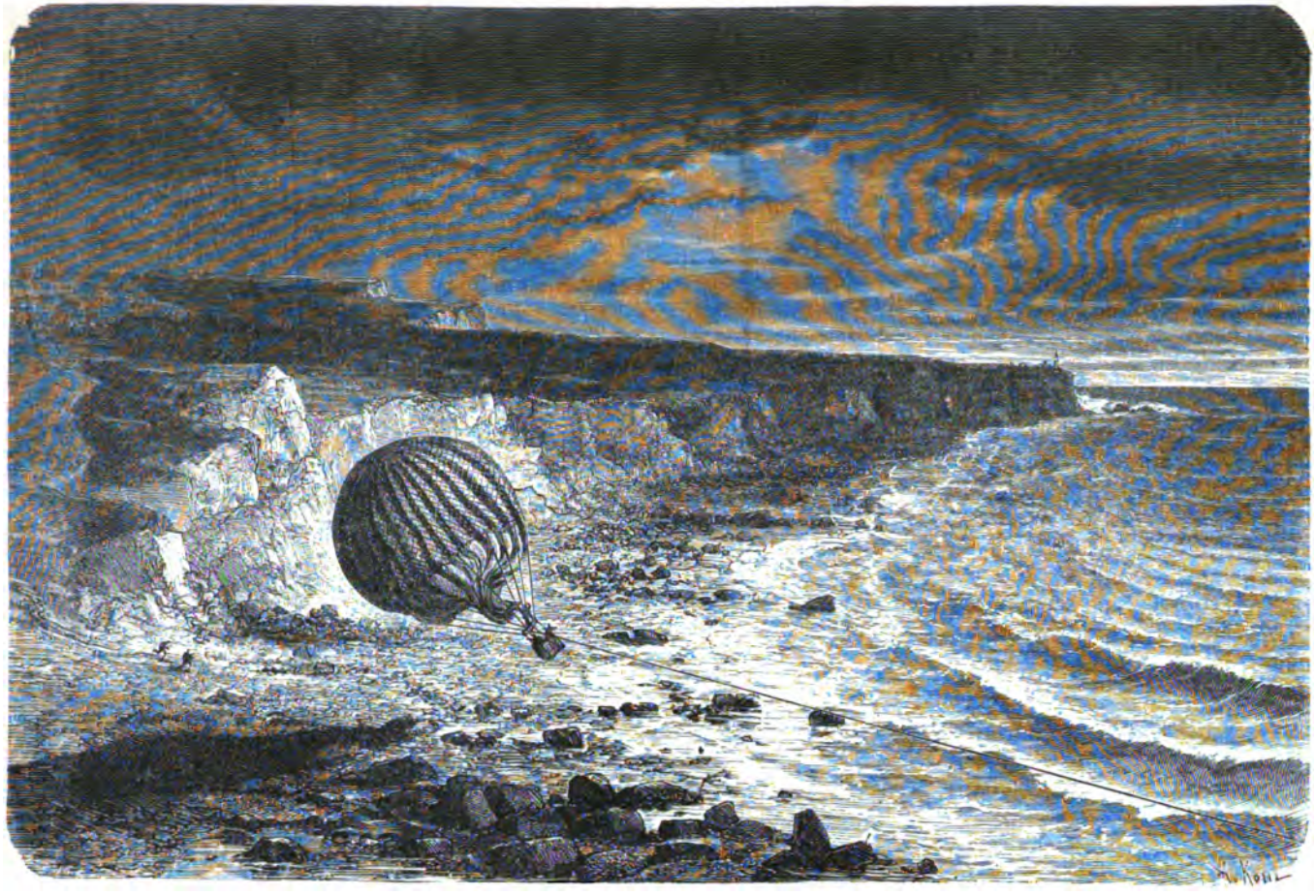

DESCENT OF THE "NEPTUNE" AT CAPE GRIS-NEZ.

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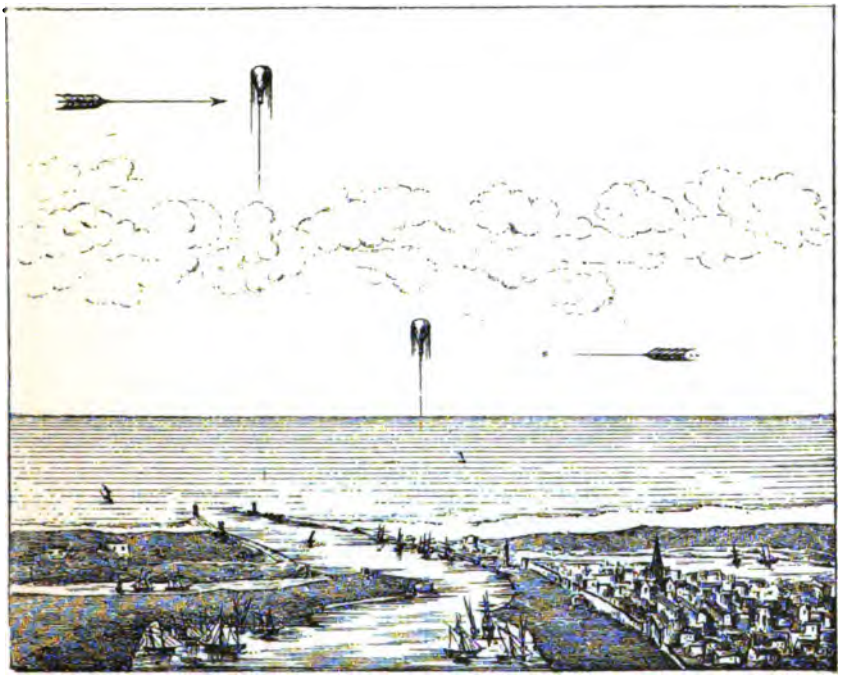
without fear to the gusts of wind outside, and the distant roar of the sea. We prolonged our festivities with the fishermen until late at night, and then retired to rest. Being unable to sleep from the attacks of certain insects that have no wings, and hence appear to be doubly vicious towards aëronauts, we all decided upon rising from our couches at three o'clock in the morning, and taking a stroll among the rocks in the neighbourhood of Cape Gris-Nez, which are little known, and well deserve a passing visit. At five o'clock we were



DIRECTION OF THE AËRIAL CURRENTS ABOVE CALAIS, AUGUST 17, 1868.

joined by our last evening companions, and with their assistance we carted the *Neptune* to the railway station of Marquise, a distance of a few leagues only, and in two hours the train carried us back to Calais.

In this expedition, as I reflected upon it during my journey back to Paris, we have had the rare good fortune of recognizing the opposite directions of two currents of air, and of being able to profit by them; going out to sea by the one, and being brought back to land again by the other, in the course of an excursion of some three hours'

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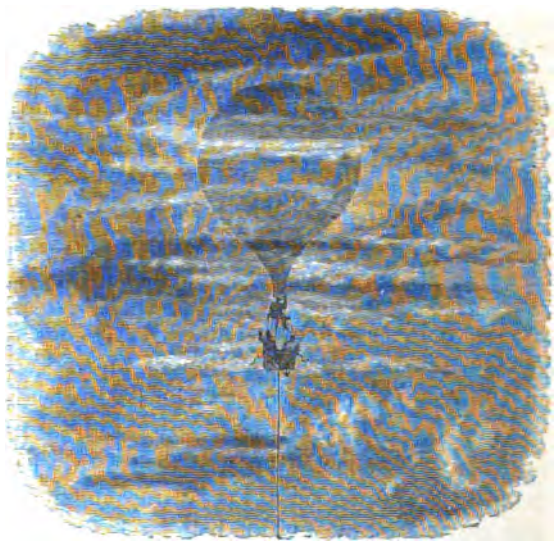
duration. This points clearly to what might be done by balloons were we possessed of a thorough knowledge of the direction of the winds.

In our mind there exists no doubt that the atmosphere is often divided into various sections, each having a current in a particular direction, and that an aëronaut, by rising or sinking into them successively, might direct his course like a bird. Had not night overtaken us, we might have confirmed this notion, by repeating an experiment more than once; or we might have profited by the currents, and tacked towards the shores of England, just as a sailing vessel would do upon the water. There can be no doubt that the question of aërial currents is one of the greatest importance to aëronauts. What is known regarding the mechanism of the general motions of the air? Scarcely anything. And how can it be otherwise, when the observations, whether taken at sea or on land, are all made on the surface of the earth, where a thousand local causes interfere to render the problem more complicated than it really is? Who can say that aëronauts will not some day discover a true system of circulation in the atmosphere, with its various veins and arteries, its regular and periodical currents, and its gulf stream, the course of which a balloon will be able to follow as surely as a sailing vessel glides over the surface of the mighty ocean?



THE "NEPTUNE" IN THE CLOUDS.

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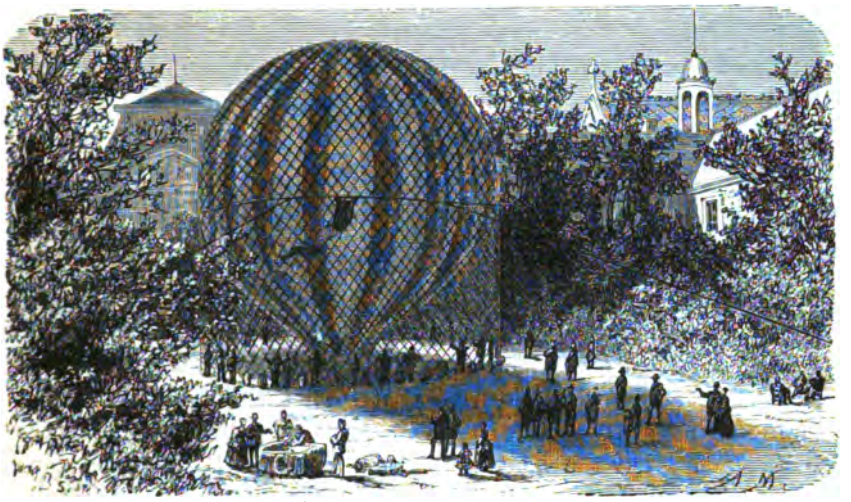

THE "NEPTUNE" AT THE CONSERVATOIRE.

CHAPTER V.

FORTUNE AND MISFORTUNE.—VOYAGE FROM THE CONSERVATOIRE.

(W. DE FONVIELLE AND G. TISSANDIER.)

THE next morning, at seven o'clock, I was at Paris. For two nights I had not closed my eyes, yet I was so much excited by my balloon adventure that fatigue had no hold upon me. Some friends were waiting for me at the station, and I had to give, for the hundredth time, a full account of my excursion. They brought me the *Figaro* of the day before, which contained an account of it, but had omitted to allude to the existence of the two currents of air. I thereupon set off at once for the office of that journal to correct the said opinion, and then, in the afternoon, to the Conservatoire des Arts et Métiers, where I met, at the door, my old friend Fonvielle, whom I had not seen since we planned out the *Bibliothéque des Merveilles*, for which we had each written several volumes. Fonvielle gave me an enthusiastic reception, and asked hundreds of questions about my first balloon exploit. We proceeded to dine together, and whilst at dinner he wrote an account of the voyage, which appeared next day in the *Liberté*, and endeavoured to convince me that I had made one of the finest maritime ascents that had ever been undertaken. In fact, he spoke so much about it, and so eloquently, that at dessert I stood up,

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stretched myself to my full height before a large mirror, and began to think that really I must be made of the stuff of a great aëronaut!

We spoke much about the scientific use of balloons, the numerous experiments that might be made in them. De Fonvielle gave some account of his first attempts, and I, as a chemist, made known the experiments which I intended to undertake upon the composition of the air, the nature of atmospheric dust, and the instantaneous crystallization of super-saturated solutions. Finally, we agreed to make an ascent together and carry out all these views.

Encouraged in our undertaking by General Morin, the director of the Conservatoire, we decided to start from that establishment, and Duruof having returned from Calais, the new crew of the *Neptune* soon planned out the next excursion. The first thing to be done was to borrow instruments to carry out our intended experiments. M. Richard lent us one of his finest barometers; M. Tresca, an excellent chronometer made in England, an anemometer, and a psychrometer. Besides these we had several thermometers, a compass, and a telescope. M. L'Hôte was kind enough to prepare some ozonometric papers for us, and in the chemical laboratory of the Union Nationale I filled some flasks with a super-saturated solution of sulphate of soda, and some tubes of thin glass with gun-cotton, destined to collect the dust of the higher regions. A medical gentleman recommended us to observe the heat of the pulse when high in the air, so we procured the ingenious little apparatus called a sphygmograph, invented by our friend Dr. Marey.

It now remained to treat with the gas company for a cheap supply of carburetted hydrogen, and then to run to the Imperial Observatory and endeavour to ascertain what kind of weather we were likely to have. But it was four o'clock, and not a soul at the Observatory; moreover, we are to start on Sunday, and no meteorological observations are taken on that day.

No person who has not organized a scientific expedition in a balloon can have any idea of the number of requisite preparations and of the time necessary to carry them out. For my part, I had to run nearly all over Paris to obtain the information and various pieces of apparatus which I required.

At last, on Sunday, the 13th September, we were ready to start. Early in the morning M. Duruof had placed the *Neptune* on the lawn of the Conservatoire, and at eight o'clock the gas was turned into it from a tube connected with the street main. By the time we had breakfasted the balloon was inflated, but the wind was high and the aërostat restless. We tried some of our instruments, and I

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counted the pulse of M. de Fonvielle with the little sphygmograph before starting.

The branches of the trees and the roofs of the building appear dangerously near to the balloon, and inspire a certain amount of fear. All our apparatus is spread out before the spectators. The wind is very strong, and causes the balloon to bound against the trees. What a grotesque and ridiculous affair if it were to burst or get torn up just as we are about to start! Some one had been unwise enough to attach a rope from the equatorial band of the aërostat to a tree. A strong puff of wind snapped it like a thread, and a hollow sound spread through the whole machine. It was a moment of intense anxiety to us! Fortunately the tissue had resisted; so we forthwith leap into the car and throw in our instruments, ballast, and provisions as quickly as possible. At twenty minutes past twelve Duruof gives the signal to let go, and we throw out two bags of ballast precipitately one after the other. The effect of this is that we rise with enormous rapidity, and nearly graze the branches of the trees and the lightning conductor on the roof of the building. In a single bound we rise to a height of 3,900 feet, and soon lose sight of the Conservatoire des Arts et Métiers.

The weather was clear, and Paris presented a marvellous spectacle as we soared rapidly over it. Our instruments were suspended to the loop of the balloon, and for four consecutive hours we made our experiments and took our observations as easily as if we had been in a terrestrial observatory.

We may pass over our barometrical and thermometrical results, which were taken down every quarter of an hour; but must nevertheless refer to the fact that an aëronaut is well situated in his balloon for proving the imperfection of our ordinary thermometers, which are acted upon much too slowly to be of much service in the air. Thus we find them rising when we feel a distinct impression of cold, and in every case their indications are too slow.

We did not take up a Saussure's hygrometer (which is recognized to be an imperfect instrument by all physicists), but a psychrometer kindly lent to us by General Morin, together with several other delicate instruments.

One of the scientific objects of our ascent was to collect any invisible corpuscles that might be found floating at great heights

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in the air. For this purpose we took up some thin glass tubes stuffed with gun-cotton, to filter the air as it passed through them; they were in communication, by means of a caoutchouc tube, with the neck of a pair of bellows, by which the air was forced through them. When the gun-cotton is afterwards taken out of the tubes, it is entirely dissolved by ether, and the residue examined under a powerful microscope.

This was done when we returned to our laboratory, and the residue of the filters being duly examined with great care, we found—must we acknowledge it?—a few grains of sand and fragments of thread. The residue of our filters was composed, then, of the débris of our balloon and microscopic fragments of ballast!

We tried another somewhat fantastic experiment. It is known that super-saturated solutions of sulphate of soda remain liquid and clear so long as they are enclosed in hermetically sealed tubes, but that so soon as the point of the tube is broken the whole solution suddenly crystallizes into a solid mass. What is the cause of this curious phenomenon? According to M. Gernez, who has made a large number of interesting experiments to solve the question, it is caused by a minute crystal of sulphate of soda, which—we cannot say why—is always to be found in the air, and, falling into the solution the moment the tube is opened, causes its contents to crystallize at once. The atmosphere, which the ancients looked upon as void, has become, for our modern chemists, the receptacle of almost every known substance, mineral, vegetable, and animal. At a height of 9,843 feet this experiment succeeded just as well as upon the ground. Must we admit that there are crystals of sulphate of soda in the atmosphere at such an elevation? Duruof is much struck with the experiment, and desires me to explain it to him; nothing would have given me greater pleasure, for then I could have placed the explanation before my readers also.

In the air we meet with another principle which is not yet perfectly known. We allude to *ozone*, which was discovered some time ago by Schönbein.

Ozone is said to be a modification of oxygen gas, but in reality its exact nature is still unknown. Its presence can be detected by the peculiar action which it has upon certain prepared papers, causing them to take a blue colour immediately. At the greatest height to which we rose, ozonometric papers turned blue. But the gas which issues from the balloon has the same effect upon them! However, by observing that common litmus paper remained red at the same time, we were assured that the balloon gas did not interfere with

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our experiment, and ozone was thus put in evidence in these higher regions.

Some day, perhaps, we shall be able to carry up a few plates of glass covered with glycerine, and to expose them beneath the November swarm of shooting stars, in order to collect the residue of these celestial combustions, as Phipson, in England, really appears to have done already.

It is generally admitted that balloons participate entirely in the motion of the aërial current in which they are plunged, but in spite of this opinion our anemometer gave several indications during the voyage. It is true that it revolved only at rare intervals and for a short period. A precise experiment was made to this effect at 1h. 26m., when the apparatus showed that we were travelling 4½ feet per second slower than the current which carried us along. There was therefore a difference of 12 per cent. between our velocity and that of the wind. This experiment only succeeded twice during the whole of the journey. It is probable that at these moments the motion of the air was undergoing some abrupt variation, to which the balloon had not had time to accustom itself. For, in a regular stream the balloon and the air have the same speed, and the aëronaut never feels any horizontal current.

The influence of mountain air upon physiological phenomena has often been spoken of; but the experiments made under such circumstances are liable to error. The individual upon whom the observations are made is usually fatigued by the ascent, and the data obtained at the earth's surface do not coincide with each other. The use of the sphygmograph in studying the pulse of M. de Fonvielle on the ground before starting and at a height of 7,900 feet, was very different from what we expected. Generally speaking, the pulse is quicker at a great height in the air, because respiration is more active in a rarefied atmosphere. His pulse, however, was slower; and this is no doubt to be explained by the fact that he was highly excited before our departure, fearing that the wind might cause some accident to the balloon. Up above, having no cause whatever of alarm, his pulse had become notably slower; nevertheless, when the curve described by the little instrument was shown to some persons who were accustomed to use it, they declared that it indicated great nervous tension: it is true that in the atmosphere we are surrounded by phenomena that keep our mind constantly active and the senses actively engaged. We are, as it were, in the midst of a kaleidoscope, and cannot sufficiently admire the wonderfully changing aspects around us.

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The study of clouds presents numerous points of interest, and the vapoury masses of the atmosphere offer to the aëronaut the most surprising and most varied of panoramas. During the whole of our voyage we had been suspended, so to speak, in the midst of a vast arch of cloud, having an apparent diameter of at least 150°. It was very regular, very uniform, slightly darker towards the east, and appeared to follow the balloon in its movements. The sky was of a very pure blue, especially near the zenith, and the earth was constantly visible beneath our feet, even when we were at our greatest elevation. The circular appearance of the cloud around the horizon was similar to that described in the last ascent of the *Entreprenant* balloon, and which could not then be explained. Then, as now, we were in the centre of a vast circle, above which was an elegant vault of clouds, but it hid the earth from sight, and was thicker and darker in the month of April than at present. The effect is probably due to the fact that certain clouds are more transparent than others, and can only be perceived when a certain thickness of them is viewed at once. Near the zenith this thickness is not sufficient to modify, to any notable extent, the blue colour of the sky beyond: this blue tint is only extinguished around the horizon, the line of which forming a circle, the clouds appear disposed in a ring, of which our balloon constantly forms the centre and appears to carry the cloud-ring along with it during the whole time of the excursion.

The drawing which accompanies the text represents this state of things very faithfully. As the clouds were very much less dense during this ascent in the month of September than in that of April, the diameter of the circle was very much greater in this second instance, and the celestial vault was of a perfect blue tint, and quite clear, instead of being partly hidden by rounded cumuli. In order to form a better idea of the phenomenon, let us suppose a microscopic balloon placed in the interior of a slightly-ground sheet of glass. On looking up or down from the car, the aëronauts would not be aware of the medium in which they were plunged, but on looking out horizontally they would see a thick opaque circle around them.

When a balloon ascends early in the morning in bright sunshine, its shadow is very distinctly seen upon the ground, and this shadow may prove useful in determining certain important points hitherto scarcely noticed. The motion of the shadow compared to the direction of the compass-needle gives us very accurately the angle of our

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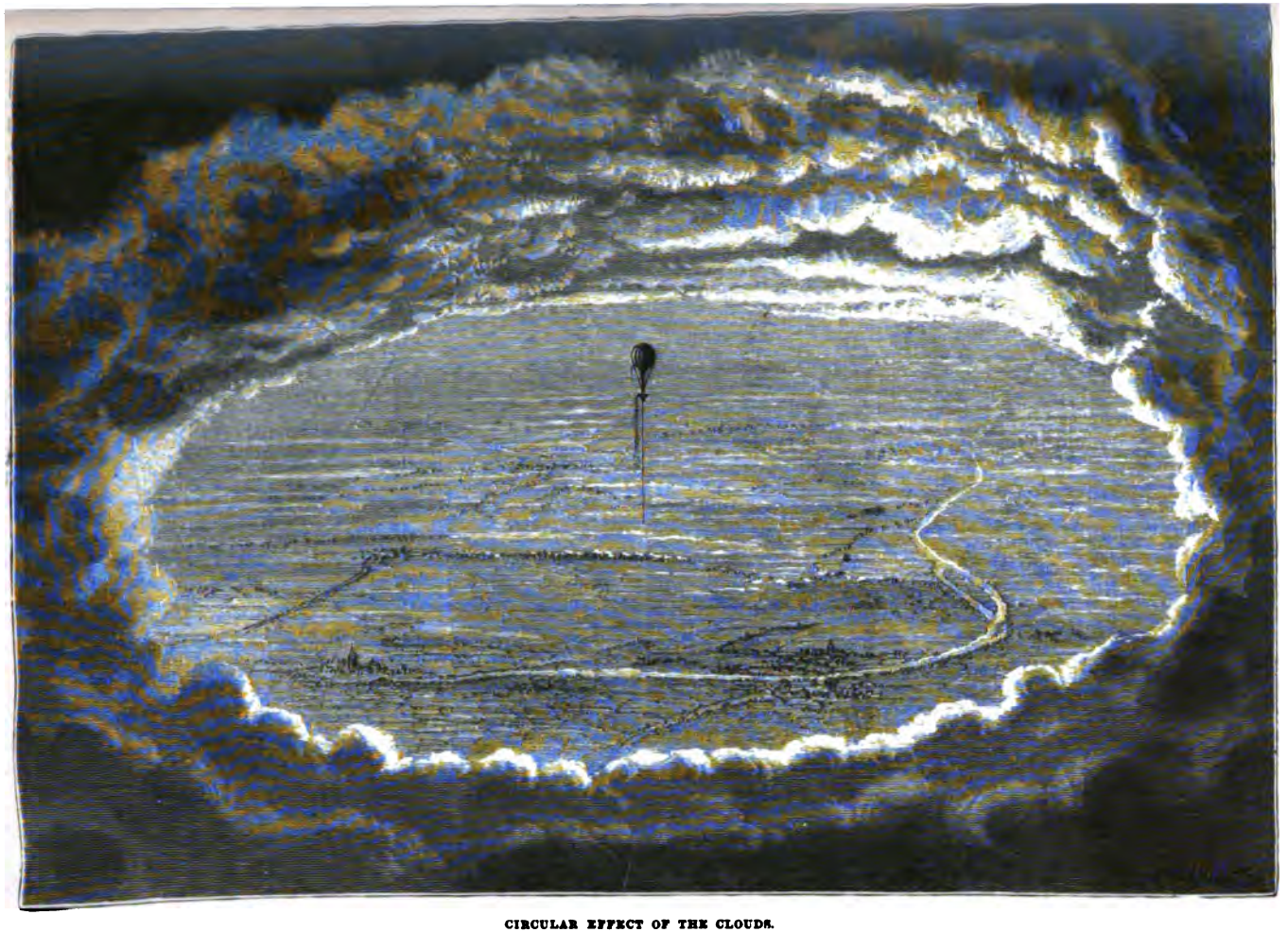

CIRCULAR EFFECT OF THE CLOUDS.

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course. It will also enable us to study the rotatory motion which so frequently occurs, and thus supply a means of correcting the oscillations of the needle.

The shadow of the balloon, hitherto so little thought of by aëronauts, may also be made use of to determine the declination of the sun more precisely than can be done by any meridian instrument; it suffices to observe it at mid-day from a spot of which we know the longitude, the latitude, and the height. Finally, it may serve to verify the celebrated formula of Laplace for the determination of altitudes by the barometer; and perhaps the moment is not far distant when the empirical formulæ of the celebrated marquis will be replaced by those supplied by the balloon. To accomplish this, it is only necessary to know the diameter of the aërostat, to measure the apparent diameter of the shadow by means of a telescope, with a reticula moveable around a graduated circle; a plumb-line would give the vertical. Thus we should have the length of the straight line joining the centre of the balloon to that of its shadow, the value of the angle which this line forms with the vertical, and to obtain the true height of the balloon we should only have to resolve the right-angled triangle thus formed.

The graduation of the telescope would be a very simple affair. It would suffice to place a disc of known diameter at the top of some high mountain, and to observe from hour to hour the shadow of this disc upon the ground, by means of a telescope, in the field of which is placed a moveable vernier. Thus we should determine the apparent size of the shadow produced by a disc of known dimensions and known altitude, which would give us the necessary bases for finding the real distance of the shadow of the balloon.

Whilst making my notes upon the shadow of the balloon, I took an opportunity for throwing overboard one of the numerous bottles which had become a source of inconvenience to us. I saw it fall, and followed its course with intense interest. Never before had I made the experiment of gravitating bodies upon so vast a scale, nor could I conceive that my bottle would take an entire minute to reach the surface of the earth! But what is no less extraordinary, as the bottle participates, during its fall, in the motion of the balloon, it does not describe a vertical line, and whilst descending towards the ground it follows the course of the latter. I had let it fall over a field, but in its downward course it leaves the field and comes directly over a village. . . . If it fell with its terrible velocity upon a house, it would certainly go straight through it! . . . . Luckily it continues

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its course, passes over the village, and falls in a field at some considerable distance.

This reminds us of an anecdote that Arago told of Gay-Lussac and his wooden chair. When the latter, in making his memorable ascent at Paris in 1804, had arrived at the prodigious height of 22,966 feet, and wished to rise still higher if possible, he got rid of every article he could dispense with, in order to lighten the balloon. Among the objects thrown overboard was a common deal chair, which, as luck would have it, fell in a hedge close to a girl who was tending some sheep. How great must have been the astonishment of the shepherdess, as the poet Florian would have said, for the sky was clear and the balloon invisible; what could she have thought of this chair, save that it had been sent directly down from Paradise! This idea could only be opposed by reference to the very coarse workmanship displayed by the chair. "The workmen up above there," said the incredulous, "cannot possibly be such muffs as that!" The discussion had arrived at that point when the newspapers published an account of the voyage undertaken by M. Gay-Lussac, and so put an end to it by grouping among well-known natural phenomena what had until then been looked upon as a miracle.

Our experiments were often interrupted by being obliged to turn our attention to the management of the balloon. The neck bends over upon the hoops, and we supposed, not without some degree of truth, that the sudden snapping of the rope attached to the equatorial band just before leaving, must have made some holes in the tissue. In fact the *Neptune* had rather a singular appearance, and every now and then began to descend with extraordinary rapidity. Once, indeed, it sank nearly to the ground, and we were obliged to throw out a considerable amount of ballast to cause our aërostat to rise again at all. Four bags of ballast were thus expended, and formed a perfect rain of sand, which covered us with dust.

This may appear strange, but it is easily accounted for when we remember that the balloon, descending with increasing velocity, may sink much more rapidly than the ballast, so that the latter may fall upon those who throw it out.

When we were at a height of 7,900 feet, we experienced a very curious physical effect, namely, a sensation of penetrating cold combined with an intolerable degree of heat, caused by the direct rays of the sun. The following remarks are copied from the notes taken in the car.

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1h. 26m.—We make the experiment with the anemometer mentioned above, and note the echo that comes back to us from the interior of the balloon when we speak loud.

1h. 30m.—We are in the midst of an extensive fog; the horizon is veiled from our sight; we hear the wind as it blows along the ground; the balloon is constantly oscillating. Its shadow is still visible through the semi-transparent mist. We still hear the wind roaring along the ground as if there were a storm in the distance. . . .

We endeavour to ascertain whether the trees are much agitated by the wind, and inspect them through the telescope; but they appear quite still, standing like sentinels on guard. Suddenly we perceive a cloud of smoke and numerous sparks of fire. What can it be? Certainly not a volcano. It is a blast furnace, and we can now distinguish the men engaged at it, and the mills; the roaring noise we heard was produced by the large fan at the forge, and is accompanied by the noise of the hammers.

2h. 45m.—We think it is time to refresh ourselves, and we eat some grapes and a little bread. The liquid in the wine and water bottles, when uncorked, effervesces like so much champagne. The landscape has changed somewhat abruptly: now we have no longer poor barren plains, but a rich fresh verdure, numbers of apple-trees, fertile fields, and brilliant little watercourses sparkling in the sunshine. This must be Normandy.

3h. 18m.—The clouds seem inclined to disappear; a small town is visible beneath us. By means of our telescope we can discern groups of persons looking at us, and, though they appear so small, their attitudes and gestures denote marked surprise.

4h. 30m.—The balloon is revolving. . . . We are sinking with very great rapidity.

Our notes were cut short at this point, for we had no more ballast, and it was necessary to provide for a safe landing.

The blast was heard rushing through the trees, and a kind of presentiment came over us that the descent would be a rough one. We hastened to take every precaution, among others to pack up our glass objects, our scientific instruments, and our wine and coffee bottles.

When we had come to within sixty yards or so of the ground, the guide-rope touched the earth, and Duruof let the grapnel go; but it ran over the ground with great speed, and took no hold at all.

The anchor when let out met with a similar fate; it hurried over the ploughed soil, sticking now and then into the roots, and pro-

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ducing a series of violent joltings which shook us considerably. Our critical situation then became evident to us. The trees, which viewed from on high appeared so quiet, were now tossing and bending their heads before the tempest, and the wind was carrying us along at a frightful speed. In the midst of all this the valve-rope escaped, blown out of reach. Duruof climbed up the side of the car to catch it. At this moment we seemed to be lifted up by a gust of wind that seemed to rise from the earth beneath us, and I was busily engaged in stowing away the loose bottles, that might have injured us seriously in case of bumping, when I heard a sharp cracking sound, and Duruof immediately cried out, "The balloon has burst!"

It was too true: the *Neptune's* side was torn open and transformed suddenly into a bundle of shreds, flattening down upon the opposite half. Its appearance was now that of a disc surrounded with a fringe! We came to the ground immediately. The shock was awful. Duruof disappeared. I leaped into the hoop, which at that instant fell upon me, together with the remains of the balloon and all the contents of the car. All was darkness: I felt myself rolled along the ground, and wondered if I had lost my sight, or if we were buried in some hole or cavern. An instant of quiet ensued, and then the loud voice of Duruof was heard exclaiming, "Now come from under there, you fellows!" We hastened to obey the voice of the commander, and found that the car had turned over upon us, and shut us in like mice in a trap!

The sun shone forth gloriously again shortly afterwards, and Nature appeared to smile upon us: though most persons would say that the wind was blowing strongly, to us it seemed much calmer. . . . . A few fragments of the balloon were to be seen floating away before the breeze. The remains of the balloon itself were flat upon the ground; not an atom of gas remained in the envelope. . . . The first thing we did on looking into each other's faces after this catastrophe was to burst into a fit of laughter! We could not understand it at all.

Some peasants ran up with anxiety written upon their countenances, and wide-gaping mouths: they had seen us weathering the gale, pulling down branches of the trees, bounding over the houses, and they also saw the balloon split up. They saw us come to the ground like a lump of lead, and they expected to find our dead bodies in the car. The hilarity consequent upon this extraordinary adventure had not subsided when they came up. They helped to

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"THE BALLOON HAS BURST!"

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look after the wine and other contents of the aërostat, for which we promised to pay them well.

We left Duruof to pick up what remained of his *Neptune*, and went off to explore the neighbourhood. The anchor-rope, which was still hanging from the summit of a poplar-tree, helped to explain the mystery of our sudden contact with the earth. The anchor, after sliding along the ground for some distance, ran into a pond, and scraped along the muddy bottom of it; on rising out on the other side, it stuck fast in the masonry which enclosed this end of the pond, and our course was thus suddenly arrested. The neck of the balloon was driven violently against the network by the wind, so that the gas could not escape from the interior, and the balloon, being compressed by the force of the gale, rent open. The wind then came to our assistance, for the balloon was transformed into a kite: at about the height of the towers of Notre Dame it blew into the remaining tissue of the aërostat, and inflated it like the sail of a ship. But the anchor being fairly fixed, and the rope stretched to its utmost, we were finally brought to the ground; the hoop was jerked away from the car, and the latter turned upside down. Duruof, who was standing at the edge of the car, was thrown out, and we were shut in by its turning over upon us.

We found that we had descended at Saint Germain d'Aulnay (Orne), about eighty-five miles from Paris, near a hospitable farm-house, the amiable mistress of which invited us to dinner. The postillion of the village assured us that the wind had been so strong all day that he had been obliged to drive his coach into a wood to protect it from the hurricane. This was at the precise moment when we took it into our heads to come down!

A few days later the *Neptune* returned home like an old invalid, covered with wounds. The wind had turned it completely inside out like an old umbrella. The hoop was broken, the anchor bent, and its rope, which was 230 feet long when we started, was stretched to 253 feet by the power of the wind.

Duruof would not make use of the india-rubber hoop invented by M. Giffard: he found it too heavy. Now he thinks better of it; but the lesson will have cost him about 20*l.* for repairs. The *Neptune* is not dead, however; and after passing through expert hands will be again equal to the task of confronting new dangers and realizing new triumphs.

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OUR MISFORTUNE AT HAVRE.

De Fonvielle was very anxious to make a maritime ascent, and we began now to plan out an excursion across the English Channel.

At Havre the sea is much wider than at Boulogne, but there is less fear of being carried over the German Ocean; and then there was an International Maritime Exhibition at Havre, which might be the means of our getting the requisite amount of gas gratuitously. The time of year was also favourable for making the attempt, or appeared so to us. Thereupon Duruof wrote to the mayor, and Fonvielle published an article in the *Liberté*, making known our project. The authorities were very cold upon the subject, objecting that there was no convenient place for making a balloon ascent; but the article produced some effect, and the public seemed much interested in so hazardous an undertaking.

On Thursday, the 24th of September, 1868, I received a visit from Duruof, who, nothing daunted, had written to the director of the Bull Ring at Havre, saying that he would make the proposed ascent for 800 francs (32*l.* sterling). The director telegraphed to him to this effect: "I accept your proposition for next Sunday, but refuse it for any later period."

We should have to make use of the *Entreprenant*, for the *Neptune* was not yet healed of its wounds. We ran to Fonvielle, who agreed to this, and Duruof telegraphed back to Havre to the effect that the ascent would take place at Havre on the Sunday following, at two o'clock.

We commissioned Duruof and Charles Chavoutier to make an inspection of the balloon, and to pack it up at once if they thought it in a fit state for use. But M. Duruof, having agreed to make the ascent at any risk, thought he would put off this inspection till the balloon arrived at Havre. The fact is, he was afraid, he said, to find the balloon unfit for use. . . . A singular mode of reasoning!

On Saturday morning Fonvielle and Duruof left with the *Entreprenant* balloon, and at midnight I joined them at Havre. "My dear friend," said Fonvielle, with a crestfallen countenance, "here are all our names on the placards, and every one is talking about the ascent to be made to-morrow. The wind is blowing towards England, but the balloon is full of microscopic holes, and is not capable of remaining in the air more than an hour!" What was to be done?

We enter our hotel and consult together. Duruof is quite done up. We had made an engagement with the public, and nothing remained

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but to fulfil it. The two brothers Chavoutier arrived by the next train with a quantity of varnish and oilskin, and at four o'clock in the morning we set to work to repair the damage sustained by the veteran balloon. We must make the ascent at all risks, and as the time we shall require to reach the coast of England will be at least four hours, we must economize our weights and take as much ballast as possible. If needs be, Duruof shall be left behind—he will be very angry no doubt, but it is not his balloon—and we will take neither anchor nor guide-rope, if we cannot do otherwise.

Such were the reflections that passed rapidly through our thoughts whilst Duruof and Chavoutier went off to inflate the balloon at the Bull Circus. The wind rose about this time and blew in violent gusts. We took a stroll along the jetty, and found that the wind had changed since morning; it was now blowing inwards towards Belgium, so that we should probably have to make a terrestrial journey after all. But some sailors told us this was not so; that the wind blew along the coast, and that it would certainly carry us over the German Ocean across the Straits of Dover!

This caused us to reflect, and called up some very unpleasant thoughts. After breakfast we felt better, and proceeded to the Bull Ring. The balloon was inflated, but the wind really terrible. The public flocked in and filled some of the seats of the arena, but the greater number walked about outside, decided upon not entering the circus till the last moment. This was lucky.

We inflated our life-buoys with great care, and placed all our things near the balloon, the sight of which, fully inflated, inspired us with new courage. We were about to start.

Suddenly, one of the soldiers who were holding the ropes of the *Entreprenant* called our attention to the fact that the wind had split open the balloon. Duruof seized upon the opening and attempted to close it; it was more than a yard in length. The balloon as it bent over with every violent gust of wind showed the frightful extent of it. It was found impossible to mend it hastily, and in face of such a gale. Just then the public began to enter the arena in great numbers. What was to be done? The director of the bull-fights saw our troubles. He recognized the influence of the weather upon the undertaking, and was kind enough to help us out of our difficulties. "If you will close the doors," we said, "to prevent any more people coming in, and will return the money to those inside already, we will see that they leave the place quietly."

The director having given us *carte-blanche* to proceed as we thought proper, Fonvielle made a speech at one side of the arena,

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and I at the other. We explained how it was that we had come here, not for the sake of the money, but to make an interesting experiment with the balloon; that the latter had been torn by the violent wind, and that it was impossible to repair it in such weather, &c.

We had scarcely finished speaking, when the balloon sank flat down. Another rent had made its appearance, and all the gas escaped suddenly. Fortunately for us, the public accepted our explanations and applauded us. Alexandre Dumas, the novelist, who was present at our misfortune, shook hands with us and consoled us, whilst the mayor congratulated us at not going up in such gusty weather. In fact, the wind blew so violently that the public seemed rather to wish the ascent not to be attempted.

THE CAPTIVE BALLOON OF PARIS.

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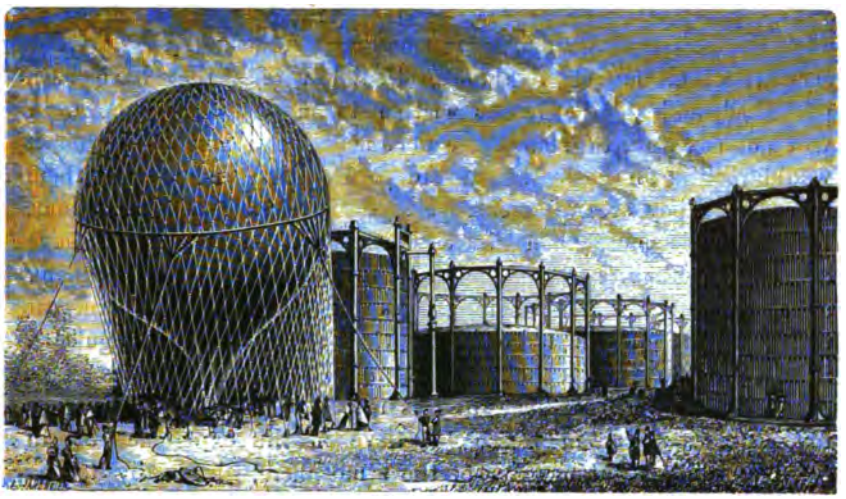

DEPARTURE FROM THE GASWORKS OF LA VILLETTE.

CHAPTER VI.

SNOW AND SUNSET.—ASCENT OF THE "UNION."

(G. TISSANDIER.)

FONVIELLE was in London, and thinking about an ascent which we were to make in an immense balloon of some 353,000 cubic feet capacity, which M. Henri Giffard offered, with his usual liberality, to place at our disposal. Whilst my companion was holding long intercourse with Mr. Glaisher and with Mr. Green, the celebrated English aëronaut, I thought I would attempt another aërial excursion myself. My brother, who was engaged to execute some of the drawings for this volume, would lose nothing, I thought, by a journey into the clouds he was called upon to depict.

A few days before starting I received a letter from Fonvielle, in which he informed me that he had seen Green, and had had a long intercourse with him. He had discovered his elegant little house, Aërial Villa, at Upper Holloway, pleasantly situated on a hill, among groups of houses and trees. He knocked at the door of the veteran aëronaut, and was very cordially received by the old man. He took my companion into the dining-room; and whilst they were discussing a glass of wine, he pointed to a well-filled portfolio in the corner of the room. "That contains," he said, "the

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account of all my aërial travels, all the articles that have been published, and all the letters written to me upon the subject. I will not ask you to read these documents," he continued, "for it would require an entire lifetime to peruse them and to put them in order. They are numerous, for my ascents have been numerous. I have made more than six thousand aërial excursions. I have crossed the English Channel three times; and I have had as many as seven hundred persons in the car of my balloon at different times, among whom I could mention some very distinguished names, and one hundred and twenty ladies. The ladies have always shown great courage in this respect. If you wish balloons to become popular in France,—believe in the experience of an old man, an ancient mariner of the atmosphere,—begin by taking women in your balloons; men will be sure to follow."

Green then took Fonvielle to the end of a narrow court, and quietly opened the door of an outhouse. Inside was the celebrated *Nassau* balloon, the hero of so many exploits. The old aëronaut was quite overcome when he stood before this splendid aërostat that had so often carried him through the air. "Here is my car," he said, touching it with a kind of solemn respect, "which, like its old pilot, now reposes quietly after a long and active career. Here is the *guide-rope* which I imagined in former years, and which ever since, as you know, has been found very useful to aëronauts. And there," he added, "is the tissue of the *Nassau* itself;—poor old balloon, I love it like a child. I have made thirty ascents with it, and have travelled in it from London to the heart of Germany."

"How happy you ought to be," he continued, "to be able to carry on scientific and artistic researches in the air. I would like to have done so too, but I could not follow my own plans; I was an aëronaut by profession, and had to gain my bread by it—want of money prevented me from carrying out the numerous experiments that suggested themselves to me. Now my life has passed and my time is gone by, but let me shake you by the hand and wish you sincerely every success. In the atmosphere there is much to be discovered! Though my hair is white, and my body too weak to help you, I can still give you my advice, and you have my hearty wishes for your future."

Whilst pronouncing these words, Green shook Fonvielle cordially by the hand, and the latter fancied he saw a large round tear standing in the bright eye of the celebrated old man. It was only at a late hour of the night that Green would consent to interrupt

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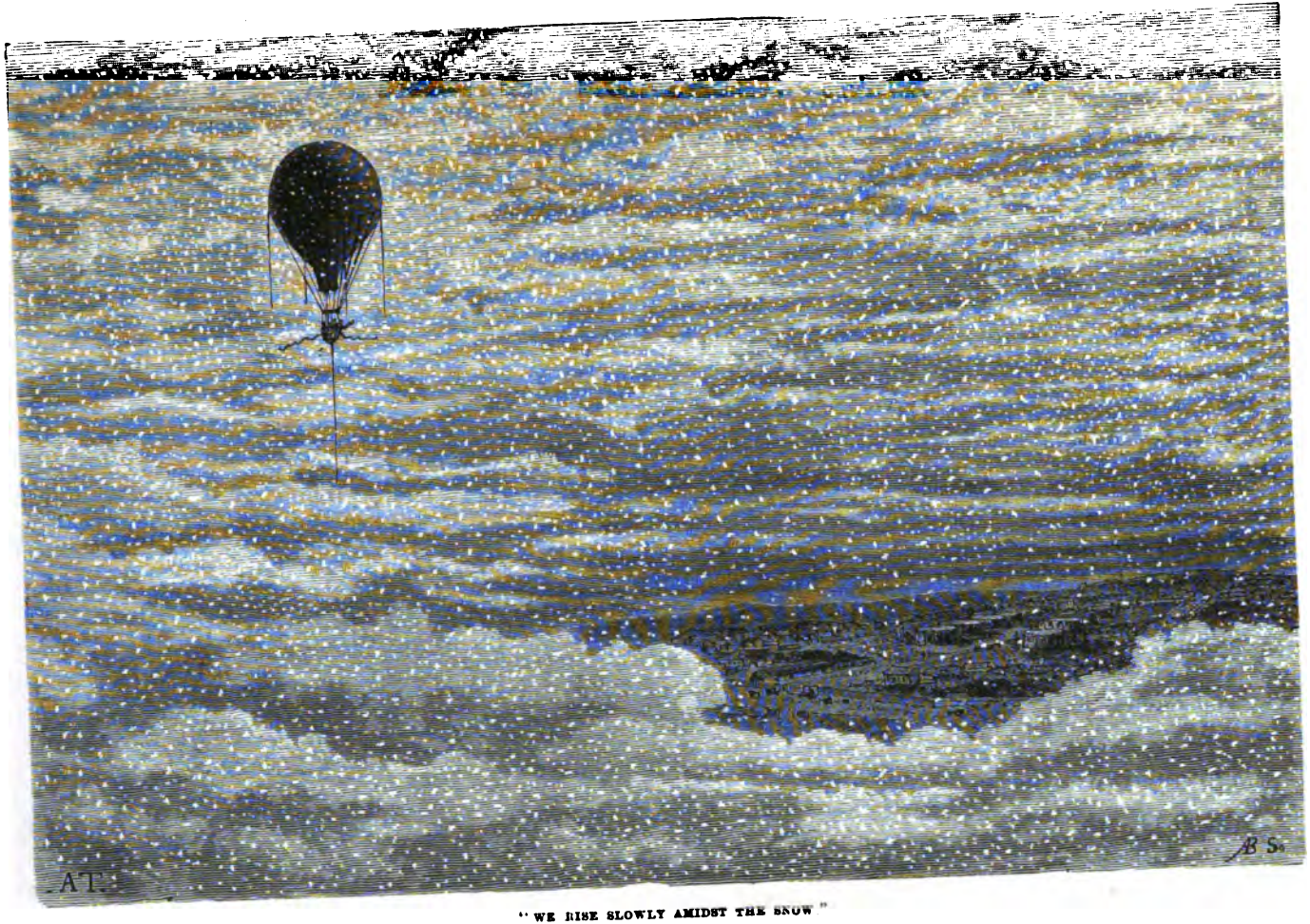

"WE RISE SLOWLY AMIDST THE SNOW"

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this conversation that led him back to forty years ago, and reminded him of his daring adventures.

The sky was very misty on the morning of Sunday, the 8th of November, 1868. I had fixed that day for making my ascent, and I did not wish to postpone it with a chance of having less favourable weather. Early in the morning, the aëronaut, Gabriel Mangin, inflated the *Union* balloon with his usual expertness.

At eleven o'clock the aërostat was balancing itself gracefully in the breeze; my brother and myself took our seats in the car together with our new captain, and a photographer who had come forward with his camera demanded permission to take a proof of us. I grouped the spectators around the balloon, and kept my companions quiet in the car, and in spite of the darkness of the morning the photographic artist succeeded in obtaining a good plate, from which the drawing at the head of this chapter was made.

We were all three in the car, and about to give orders to let go, when M. Cury, the director of the gasworks, ran up to us with a telegram from M. de Fonvielle in London. He knew we should be on the point of making an ascent, and thought he would send us the opinion of the Greenwich astronomers on the state of the weather we might expect. The text ran as follows:—

"General N.W current. Europe covered with thick clouds. Foggy weather. Snow probable."

I had scarcely read the telegram when a few flakes of snow began to fall, and thus confirmed the above prediction, for which we have to thank our colleague Glaisher.

We rise slowly amidst the snow, which is falling abundantly, and we can scarcely see the ground any longer. . . . In the distance we recognize the gasometers from which we started, and the groups of friends saluting us by waving their hands can be discerned with some difficulty through the white flakes falling around us. We were informed, later, that the balloon presented a curious appearance as it rose. It seemed to draw the snow towards it, and to fix the flakes which struck its surface; it soon appeared surrounded by an aureola of vivid whiteness; we looked like an immense icicle floating among the moving snow-flakes.

The layer of solid water thus poured upon the balloon caused us to gain weight considerably, and we could only rise by throwing out several bagfuls of ballast. By this means we finally attained an altitude of 5,900 feet, and find ourselves present at the admirable

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spectacle of the formation of snow. Just now large flakes danced around the car in a thousand irregular curves, and sported in the wind; now we have brilliant, almost iridescent, crystalline plates, which are mutually attracted and increase in volume whilst we watch them, growing considerably larger before they are many hundred yards below the car. Above our heads the cloud is less dense, more transparent, and we believe that the region of sunshine is not far off. But our aërostat with its covering of ice is not capable of rising into this region. The temperature is not very low, for the thermometer only reads 30°·2 Fahr.

I have taken several instruments with me, among others a psychrometer, which tells me that the air is not at all damp; but I regret that I have no microscope to examine the crystals of snow that fall upon my coat. But who would dream that such an instrument could ever be required in a balloon? To-day I would willingly exchange my telescope for an ordinary pocket-lens.

12 o'clock.—We have decided upon losing some ballast, and in spite of the snow we still rise. I would like to drive the balloon through the light fog that separates us from the solar rays. In seven minutes we have only risen 650 feet; it is a painfully slow ascent, but how can we overcome the weight of snow carried on the shoulders of our courier? All that we can do is get beyond the limit of 6,500 feet. The particles of ice are very fine—an endless number of microscopic crystalline needles. One more effort and we shall see the sun; we have enough ballast to enable us to rise into the sunshine through the last strata of mist.

12h. 15m.—We hold a consultation and come unanimously to the conclusion that we must not dream of rising any higher. To get beyond the last strata of vapour we should have to exhaust our forces; that is, to expend the last atom of ballast upon which our safety depends. If we were unfortunate enough to plunge our aërial chariot into the solar beams which shine above us, the heavy layer of snow on the surface of the balloon would melt at once, and, thus lightened, we should be carried up into the highest regions of the air. After admiring the scene for some time, we should be called back again towards the earth by that invisible power called gravitation, and on descending our balloon would certainly accumulate a fresh supply of snow, and so descend with great rapidity, during which time we should have no ballast to throw out, and to save us from falling to the ground with a fearful shock. We conclude, then, that to soar higher at present would be far from prudent.

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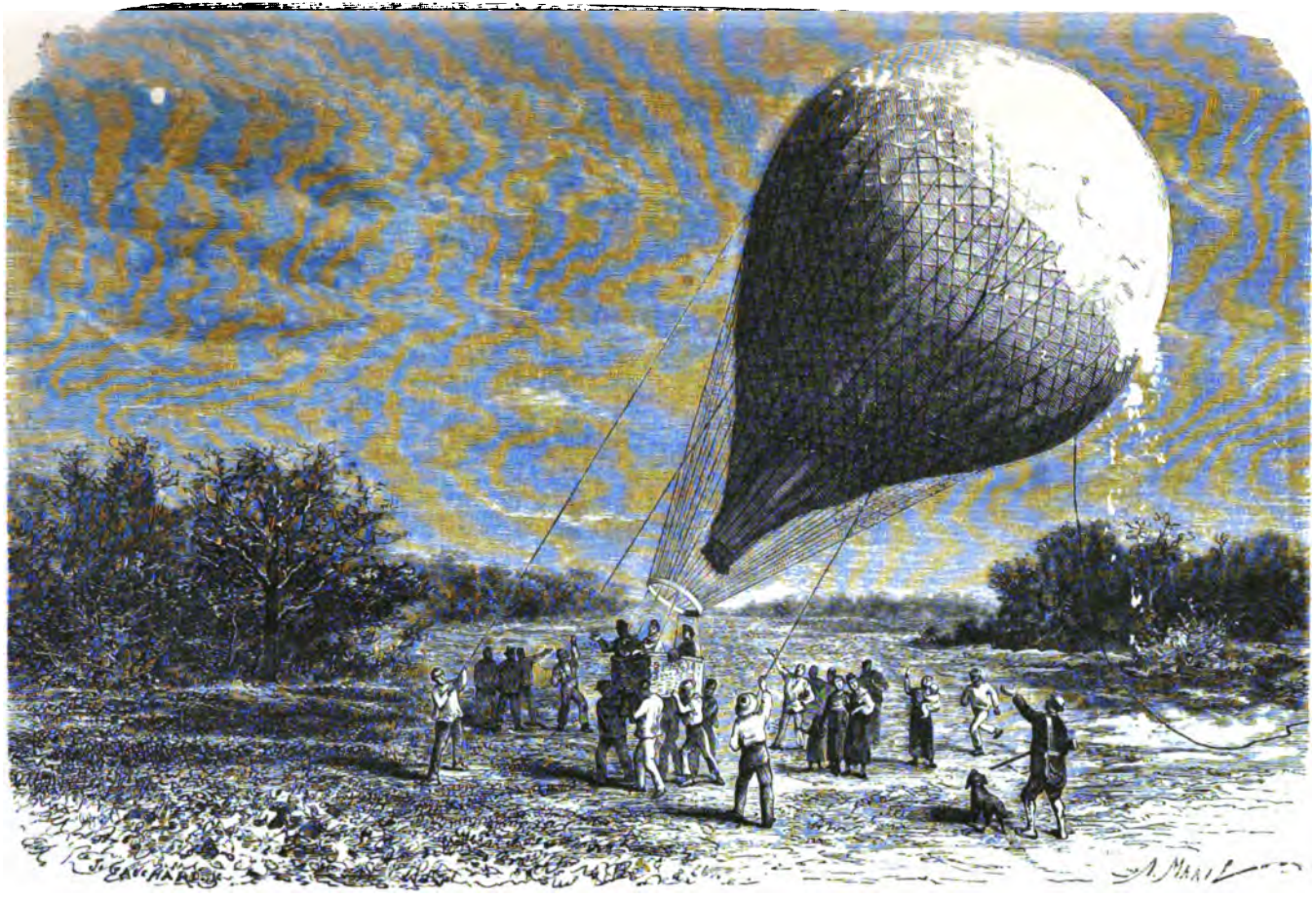

"A FEW VIGOROUS ARMS LIFT UP THE CAR."

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12h. 25m.—We can distinctly hear human voices and the rolling of a carriage. . . . . Never before have terrestrial sounds reached my ear when at such an altitude (5,900 feet).

12h. 45m.—We have sunk somewhat rapidly to an altitude of only 3,280 feet above the ground, and here we are again among the same flakes of snow, rather more numerous than before, and dancing around us in all directions. According to the psychrometer, the air still appears nearly dry.

The balloon seems for a moment to have come to a standstill, but we find it necessary to continue to pour out small quantities of sand. The snow is falling thicker than ever. How do these mysterious crystals form in an air so mild? By what marvellous mechanism does Nature shape these angular forms that are constantly created before our eyes? Are the invisible atoms of vapour drawn together by the same force which causes planetary worlds to gravitate in space? Are we not witnessing the formation of an endless number of corpuscular worlds modelled by Divine art?

At this moment our descent becomes rapid, and puts a stop to my philosophical reflections. Mangin also brings me back to stern reality, by exclaiming that there is scarcely one more bag of ballast left. The earth comes in sight rather suddenly, but the snow is so thick that it hides us from some peasants that we see upon the road below us, and to whom we call lustily for help. They turn and look behind them on hearing our shouts, but none of them think of looking up into the air. Our guide-rope soon touches the ground, and the car of the *Union* is abruptly thrown into the middle of a field. I let go the anchor, which takes firm hold in the soil, whilst Mangin opens the valve, but closes it again immediately when he finds that one rope holds fast.

Some peasants run up and tell us that we have descended at Chennevières-sur-Marne. . . . Our course has not been very rapid, for we left Paris an hour and a half ago. As it is not late, I do not wish to let out the gas, believing that the snow collected on the balloon will soon melt away and render it lighter. The weather seems to be getting clearer; and if the sun came out, it would soon dry the envelope completely, and enable us to make a second ascent.

Several persons of the district approach us, and among them M. Rouzé, who, with his two sons, had run some distance after our guide-rope. I accept his kind invitation to lunch; but I do not like to abandon the balloon, fearing that it might run away in our absence, as it was getting lighter every minute.

"Never mind that," said our hospitable host; "you shall be carried to the door of my house."

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This was no sooner said than done: a few vigorous arms lift up the car, in which we remain quietly seated, and carry us triumphantly across the fields to the road, and thence to the door of the house. Here we fill the car with large stones, and leave the balloon in charge of two honest peasants, with strict orders not to allow any smoking near it. "By lighting a pipe near the balloon," I told them, "you will all be blown up into the air!"

M. Rouzé conducts us into his charming villa, and introduces us to his amiable friends. The snow had given us a keen appetite, and we did honour to the feast. I could not help laughing at the thought that our friends in Paris imagined us, doubtless, freezing ourselves in the higher regions all this time.

After dinner I turned to our benevolent host, and said that, as he had witnessed a landing, perhaps he would like to see an ascent; and as I thought of leaving by the same road which brought us, he would be able to see one rather sooner, perhaps, than he expected.

The company present could scarcely believe it possible; but Mangin asserted that it was so, and on leaving the table we all made off for the balloon.

Our two sentinels had done their duty well. I shook hands with our hospitable friends and entered the car, together with Mangin and my brother, after having taken out all the stones one by one. But, alas! the aërostat would not move; we were still too heavy, and it would not rise at all.

The sun had appeared, and the air was calm. Mangin decided on leaving the guide-rope behind; it was rather heavy. The balloon certainly made an effort to move, but still it would not rise. We were several pounds too heavy, and regretted, rather too late, that we had breakfasted so heartily.

However, it was absolutely necessary, after what we had said, to make a start, and I was selfish enough to propose that my brother should be left out; but he would not hear of it.

Then I turned to our pilot, and endeavoured to make him believe that we could start without him. But he would not hear of it either!

All this amused the company present not a little; they could not help laughing, but we thought it no joke.

An entire hour was spent manœuvring with the lazy aërostat; at last I decided on leaving my instruments on the ground, keeping only a thermometer and a barometer in the car. We also got rid of our heavy overcoats, rugs, &c.; I replaced the heavy anchor rope by a much lighter cord, and I threw out all the empty ballast

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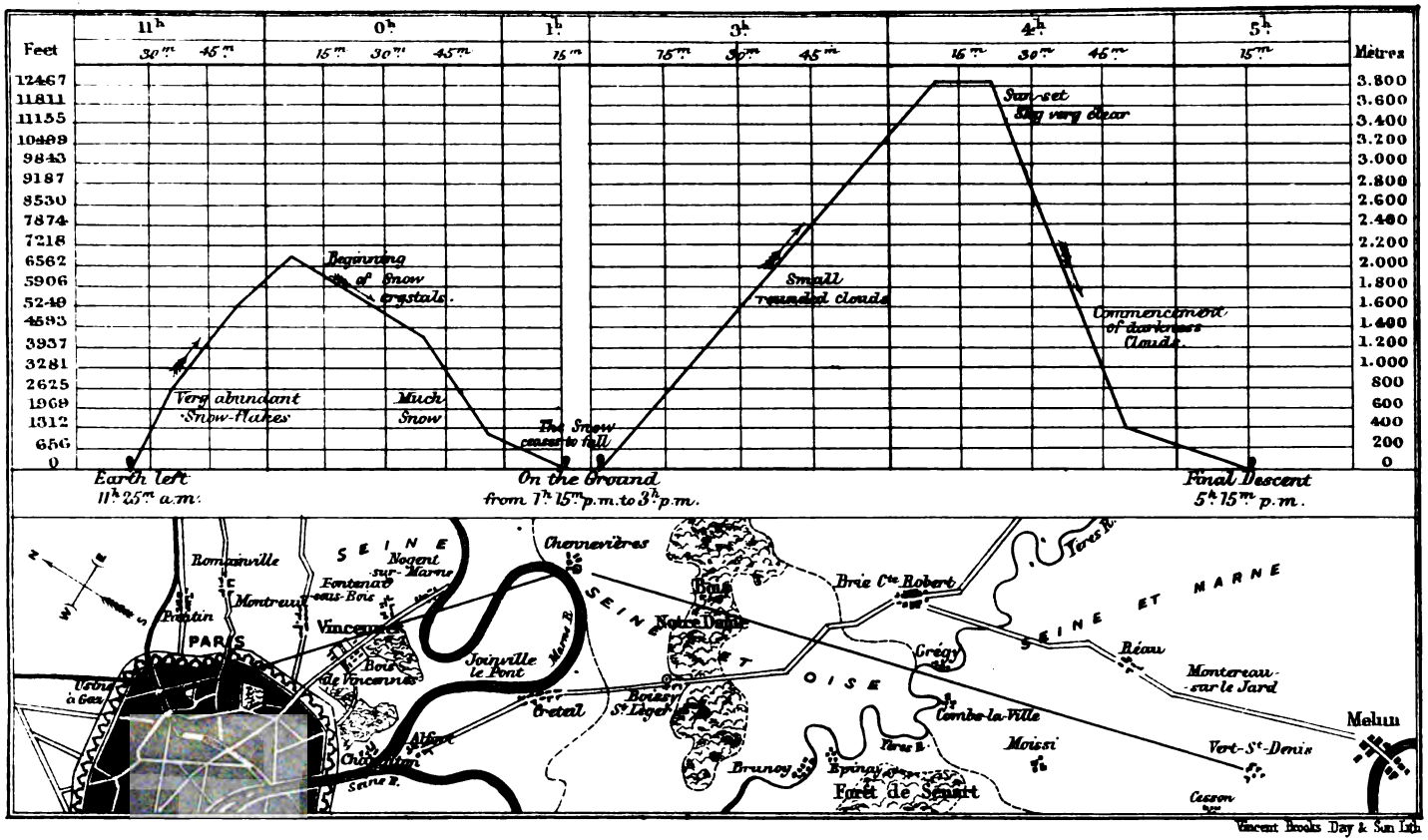

Double Balloon ascent of M. G. Tissandier,
8th November 1868.

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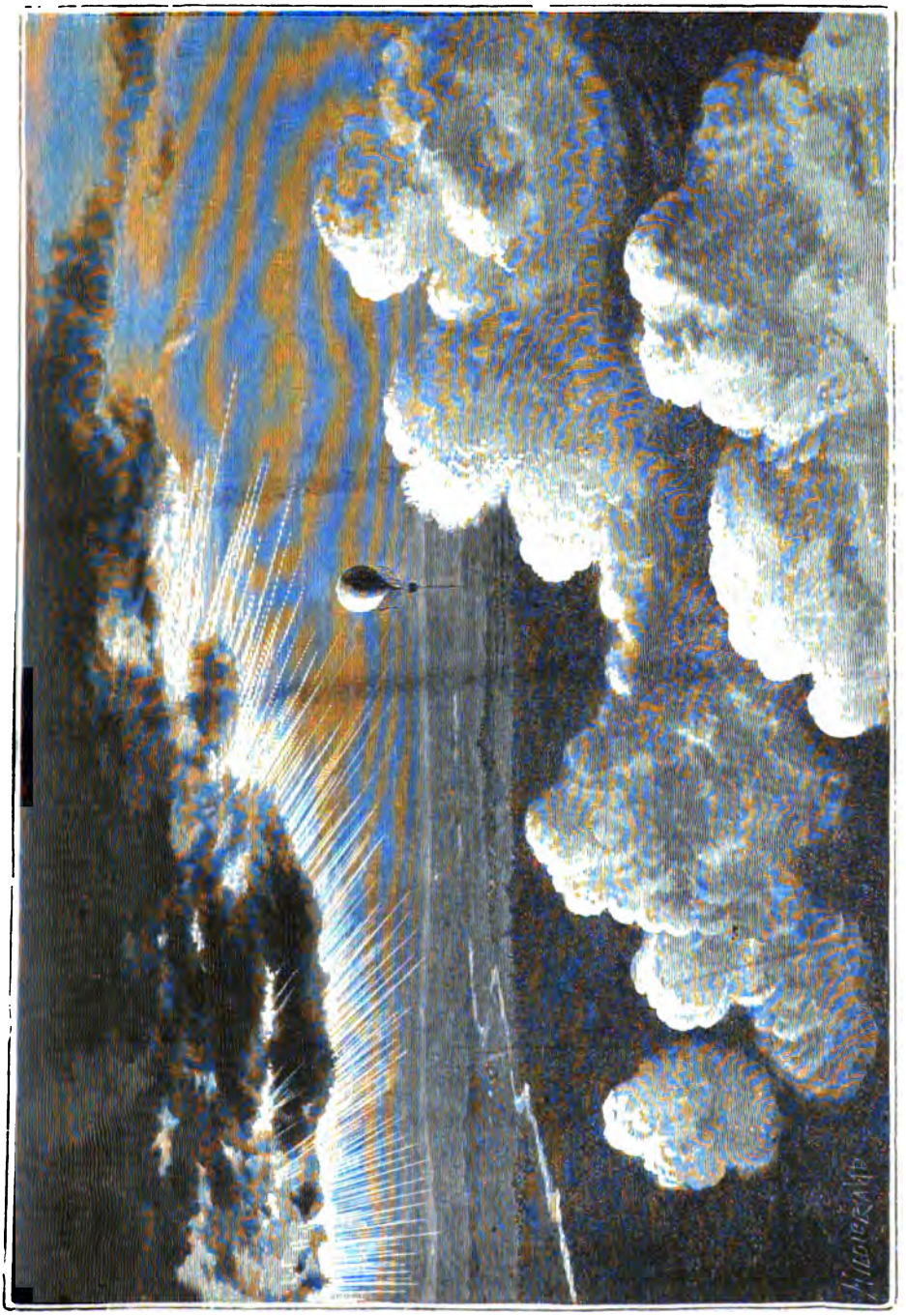

"IN ONE BOUND WE PASS THROUGH THE THICK LAYER OF CLOUD."

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bags. I believe that I would rather have left the car itself behind than not make the ascent; we could have gone up sitting in the hoop! However, what we had already done, together with the warmth of the sun's rays, that now dilated the gas a little, gave a certain amount of life to the balloon. . . . It is actually ready to start! We call to our friends to let go the ropes, and in one bound we pass through the thick layer of cloud, and float above it into the warm rays of the afternoon sun. The envelope of the balloon is quite dry . . . . it is three o'clock only, and we have a fine excursion before us.

We rise higher and higher, without touching our only bag of ballast. . . . . The temperature is lower; it is now 26°·6 Fahr., and we are 9,800 feet high.

The clouds illuminated by the sun are of a strange tint; they are of a violet rose colour, and spread in elegant forms along our horizon. But this is only the prelude to the magnificent spectacle of sunset which is approaching. . . . .

Soon the sun disappears behind a curtain of cloud that hides its magic splendour, but from behind this dark veil of purple a thousand golden rays shoot forth and dazzle the eye. They all appear to emanate from a central point, which, though invisible, can be easily traced to its proper place. No poet has ever dreamed of such a brilliantly radiating spectacle, nor imagined such dazzling lines of fire. . . . . We rise to an altitude of 12,500 feet in the midst of this splendour, whilst absolute stillness reigns throughout Nature, and it is the hour of twilight! What a sublime harmony of colours, light, and silence!

Thus suspended in the infinite realms of space, we cannot sufficiently admire, nor contemplate without considerable emotion, the last glorious rays of the setting sun, and the splendour of the clouds as they receive its celestial illuminations.

It is with a sort of ecstasy that we turn our eyes towards the earth, now only visible through the semi-transparent mist, masked, as it were, by a veil of rosy muslin. The river Marne winds across the country, and a long ribbon of vapour exhales from its blue waters. Further on is an aqueduct, the only vestige of human art in the whole glorious landscape. And what a wonderful effect is that produced by the microscopic country below, before which the mind expands whilst we contemplate it with mute astonishment! Never before had I been so surprised by the gradual changes of tint undergone by the masses of cloud whilst the sun sank slowly below the western horizon; the more vivid colours die out, and are suc-

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ceeded by rich purple tints, fringing the borders of the vapour mountains, whilst the sky above is dark indigo blue, and the earth puts on the green tint of a pale emerald. The Marne has a rosy hue, like that of the petals of newly-budded flowers, and our balloon follows its silent course amidst all these marvellous displays of colour, belonging neither to the earth nor the sky, but soaring between these two brilliantly illuminated hemispheres.

Gradually this harmonious glory of colours diminishes, the clouds pass from that rich violet tint to a cold, grey hue, whilst the country below takes a veil of opaque drapery, becoming darker and darker until it appears like crape instead of muslin. The sun is about to disappear, whilst animated nature below prepares for rest as the silent night approaches; its last luminous rays light up the higher clouds with a deep orange-red tint which is reflected far away into the distance. Even the earth participates in this last effect of the disappearing orb. So brilliant is it, however, that our eyes are still dazzled by it, when suddenly the whole effect disappears from sight, with a rapidity unknown to the inhabitants of the earth's surface, where light struggles so long against darkness. The sun hides itself beneath the horizon which screens it from our sight, and at the same instant all this magnificent display of light and colour vanishes as if by magic!

What a pity it is that we cannot keep our balloon up in the air until the morning light bursts forth and animates Nature anew! With what regret we contemplate the necessity of regaining the earth's surface, knowing that to-morrow these regions will be again lit up in the same glorious tints that have just charmed our senses. But we shall not witness the marvellous spectacle again, for, seen from the ground, the curious architecture of the clouds and their sublime tints are by no means the same. The aëronaut alone can see them in their true aspect. Up above we have an Alhambra of unheard-of richness and beauty, whose ruby fires rival those of the opal and the sapphire; below, we see the same enchanted palace with the lights and colours extinguished! . . . .

My brother was enabled to take several sketches of the aërial and terrestrial landscapes through and above which we travelled, and my meditations were now and then interrupted to read off the indications of the thermometer and barometer. Our maximum altitude was about 12,790 feet: it is the greatest height to which I have yet soared. The minimum temperature was 23° Fahr.

Though low, this temperature was by no means the Siberian degree of cold which our friends, whom we had left upon the earth, thought

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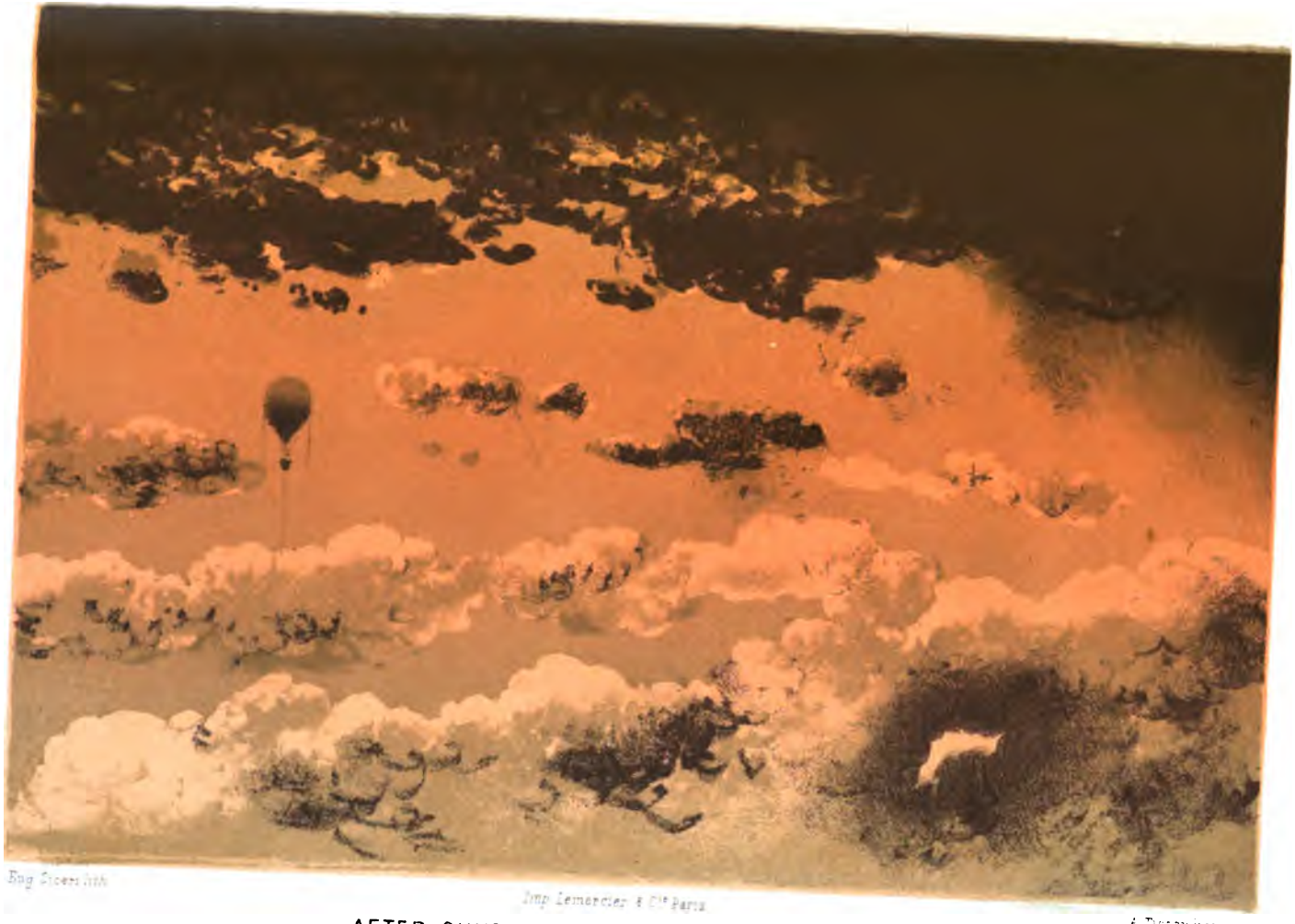

Eug. Sicard lith. Imp. Lemercier & Cie Paris A. Tissandier del.

AFTER SUNSET, AS SEEN FROM THE BALLOON

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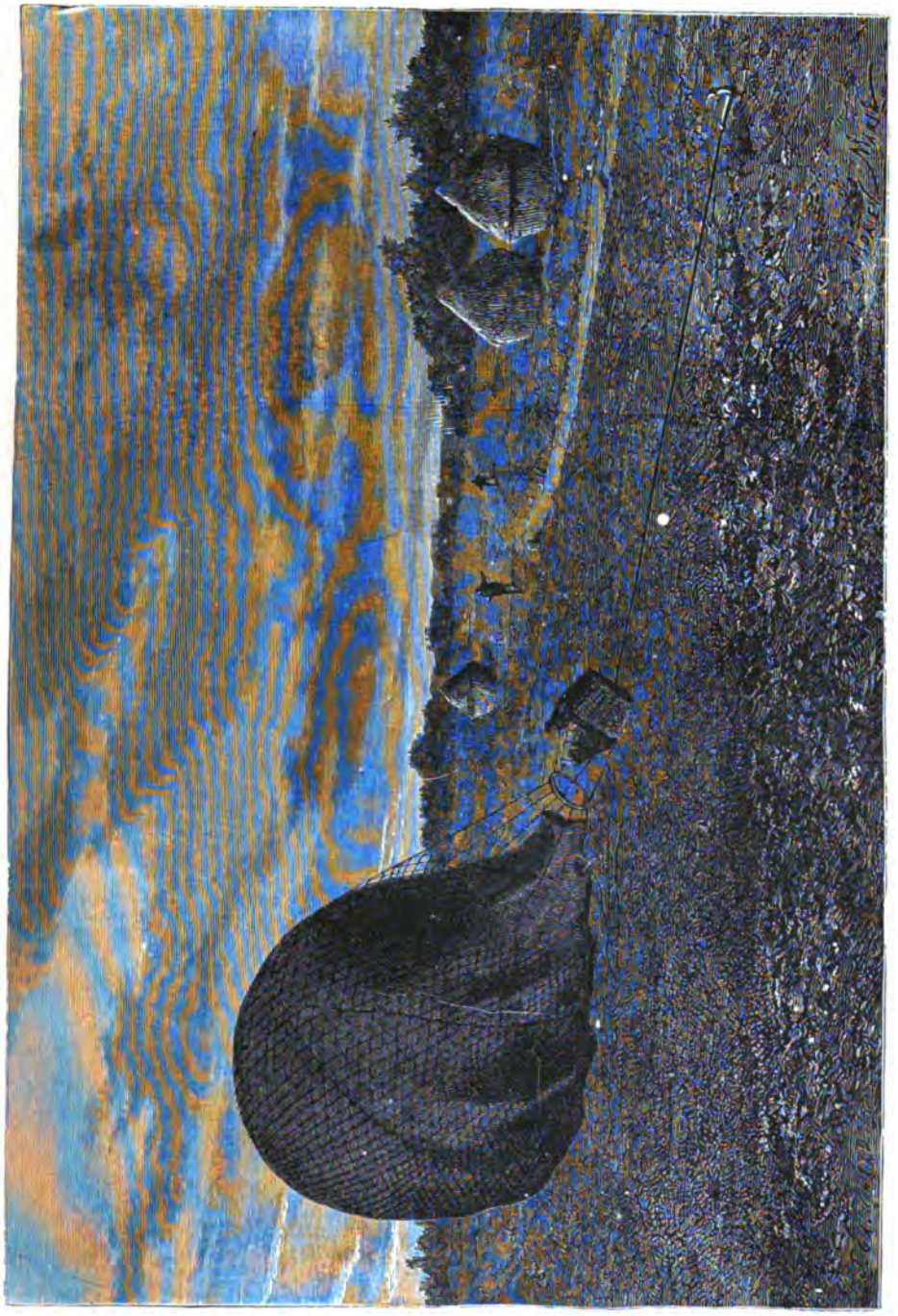

"WE FELL SOFTLY TO THE GROUND IN A FIELD."

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we should experience. We were not at all inconvenienced by it, probably because there is no wind in the car of a balloon, so that no breeze ever blows against our faces. Our breathing was by no means affected, and the only extraordinary circumstance that I noted was that our voices were not so easily propagated through the rarefied air; we were obliged to speak rather loud to make ourselves heard. Moreover, I experienced a certain buzzing sensation in the ears, and a slight pain in the tympanum. The air contained in the external canal of the ear becomes dilated as we rise, on account of the decrease of external pressure, and this may, in some cases, give rise to deafness, or to actual pain, during the ascent.

Mangin observed that it was five o'clock, and that we had better think of making our descent. The balloon was perfectly balanced in the air, and it was necessary to open the valve and allow some gas to escape. As we approached the ground, the last ray of solar light died out in the air; the atmosphere became darker, and the landscape was enveloped in the dusk of evening.

We fell softly to the ground in a field not very far from Melun, in front of those groups of trees which form the commencement of the forest of Sénart. The wind drove us along for some distance over the ploughed land, the balloon bent over on its side, and we got covered with mud. It was like coming back to stern reality after a beautiful dream!

THE "UNION" BALLOON IN THE SNOW.

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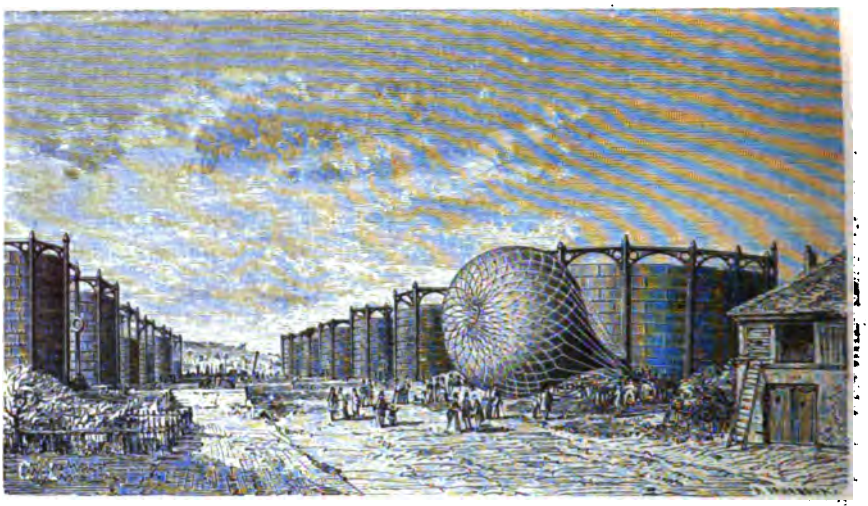

"THE 'SWALLOW BALLOON, WHEN INFLATED, LAY DOWN UPON ITS SIDE.'

CHAPTER VII.

WINDY ASCENTS AND DRAGGING.

(W. DE FONVIELLE AND G. TISSANDIER.)

OUR attention has been directed for some time past to the radiating power of the sun. It is not difficult to understand that all observations made in this direction upon the surface of the earth must meet with a great obstacle in presence of cloud or vapour, which introduces error into the degree of heat, measured to an extent which it is quite impossible to determine. The exact amount of heat radiated to the earth by the sun is a desideratum in science, and we regret that our observations have not yet supplied it. The apparatus which we had constructed with this intention consists of a blackened copper sphere four inches in diameter, in the centre of which is placed a thermometer with a round bulb. This apparatus was filled with water, and placed before a very hot flame. We noticed that its indications were not rapid enough; the mercury in the thermometer rose much too slowly. The water was then replaced by air, the interior of the copper sphere being previously blackened like the outside, and finally we decided upon having a vacuum in lieu of air in the sphere. As much time is required to study this new instrument in order to fix the value of its indication, we have

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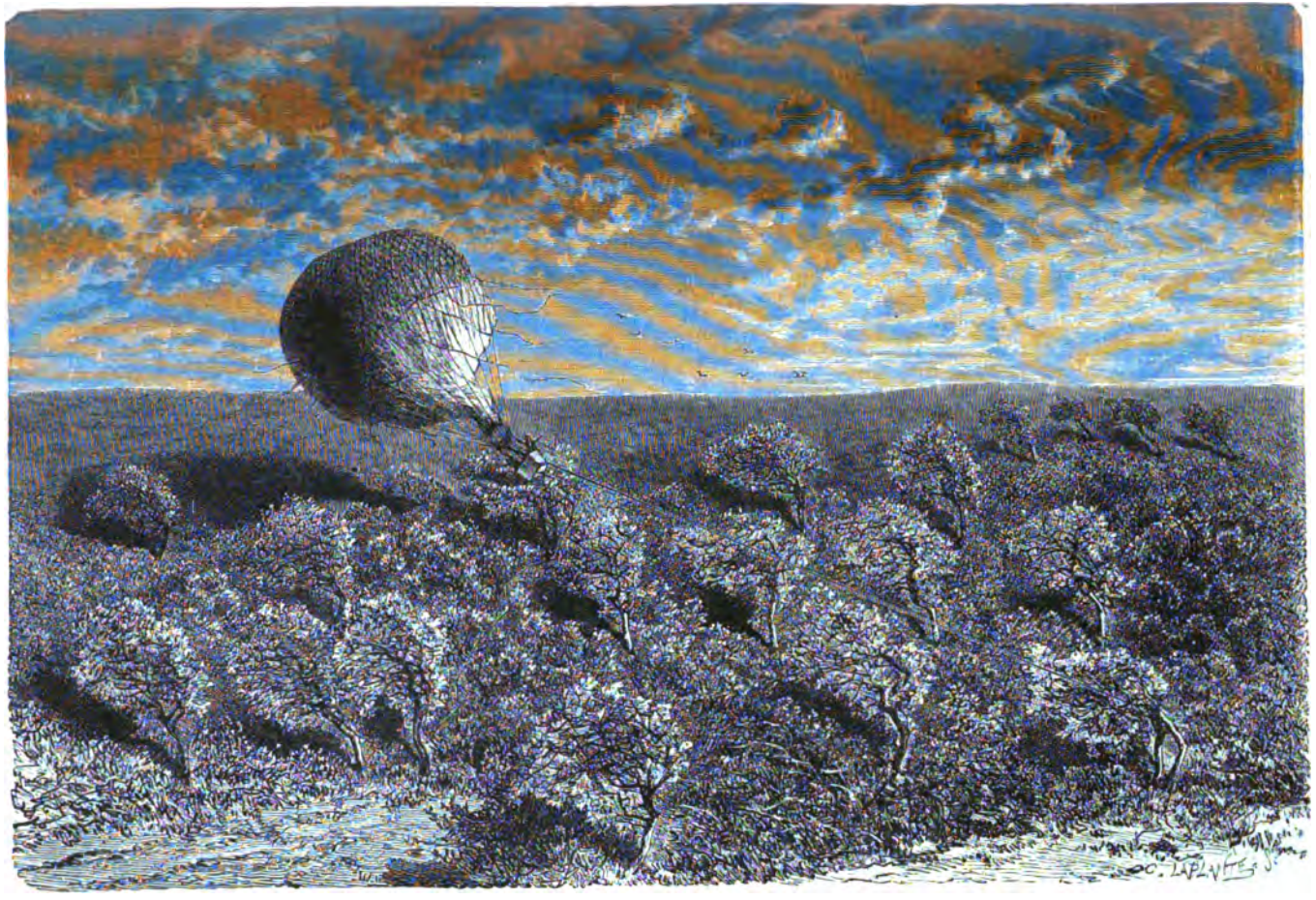

"THE BRANCHES OF THE TREES RENT BENEATH THE CAR."

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not yet been able to use it in our balloon ascents, but we have decided on calling it a *thermoheliometer*, to distinguish it from the *pyrheliometer* imagined by M. Pouillet.[1]

On the 10th January, 1869, the *Entreprenant* balloon, which had been repaired since its accident at Havre, was being inflated at the gasworks of La Villette. But the gas had scarcely entered the envelope, when the latter was proved to be quite dry and rotten; it was impossible to touch it without making a hole, and we were forced to declare that the *Entreprenant* was dead and gone! This check was rather unfortunate, for we had just received telegrams from Zurich and Madrid, assuring us of the existence of a south-east wind, which would have been very favourable to us.

We were thus without a balloon! The *Neptune* had not been repaired. However, M. Giffard had still another small one called the *Swallow*, but it also required some mending. Through the kindness of this gentleman it was clothed in a new tissue, varnished, and taken to the gasworks on Saturday, the 6th of February.

But the capacity of this little balloon was only 23,000 cubic feet, and we were not sure that it would carry us both. In order to make certain, every article to be taken with us was carefully weighed, and the specific gravity of the gas ascertained with accuracy. We were thus convinced that the anchor and the guide-rope were far too heavy, if we wished to take even a moderate allowance of ballast. In this dilemma we hastened to M. Duruof, who supplied us with the smallest anchor that could be had, and we reduced the proportions of our guide-rope to those of a weak cable. We knew that such rigging would not protect us from danger in case of a violent wind, but there was nothing else to be done, the Minister having refused us the use of the *Imperial* balloon.

The next day Chavoutier superintended the inflation most successfully, though the wind blew in great gusts. The *Swallow* balloon, when inflated, lay down upon its side, and the men who hung on to the car had much difficulty in preventing its escape. When we told them to let go, we glided upwards with such rapidity that it quite startled the lookers-on.

It was the first time that Fonvielle and myself had been alone in the car of an aërostat; we might be said, therefore, to be transformed, at last, into aëronauts properly so called. We were obliged to arrange the ballast so as to keep the car horizontal, and by some

[1] A drawing and description of the latter instrument is given in a recent work called "The Sun," by Professor Amadée Guillemin, translated from the French by T. L. Phipson, p. 25; together with the results obtained by it. (London: Bentley, 1870.)

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accident the guide-rope had got tangled. Having straightened it, we also let out the anchor to be ready for our descent.

We reach an altitude of 3,280 feet, and the heat is unbearable; on the ground before starting we had only 55°·4 Fahr., and here the thermometer stands at no less than 82°·4 Fahr. The weather is heavy, suffocating, and the perspiration rushes from our foreheads. The balloon revolves constantly—a consequence, no doubt, of the law that no rapid motion of translation can occur without a corresponding amount of rotation. The sky is clear, and we notice above the country over which we are sailing, a few fleecy clouds, that blend into the landscape over which they are suspended. Along the horizon we notice some silvery groups of cloud, which present a marvellous aspect. However, we have no time to observe Nature, for there is something about the balloon which causes us considerable uneasiness.

The neck is quite flat, and appears to be emptying itself of gas. We are obliged to throw out ballast every moment, and no less than four bags of it have been emptied, one immediately after the other. We started at 11h. 35m.; it is not yet twelve o'clock, and our resources are already expended.

A cracking noise is heard several times over our heads; the balloon revolves abruptly, and sometimes oscillates no less suddenly. There is certainly something extraordinary in the state of the atmosphere, which we cannot account for at all.

At five minutes past twelve the balloon sinks with great rapidity; and we observe that our course lies towards some quarries, ravines, and precipices. We seize upon our last bag of ballast, and a gust of wind carries us, in one bound, over a wide plain, at the extremity of which we see considerable extent of forest.

This is the spot to descend upon. The *Swallow* approaches the ground, and the car comes down with a terrible bump. Tissandier hangs to the valve-rope, and observes that Fonvielle is covered with blood. The hoop of the balloon has struck him upon the head and caused a deep wound. The car had come to the ground like a bullet, but we rose again immediately, and had to undergo several similar contusions. Our anchor fled over the ground and would not take hold of anything; it was like a cork at the end of a piece of string. We seemed to be the sport of some invisible power, that first raised us into the air and then bumped us against the earth.

We were being dragged along by the force of a furious gale!

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RETURN OF THE AERONAUTS.

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So rapid was our flight, that we could not distinguish the various objects which we passed by, and in less than a second we found ourselves thrown on the tops of the trees at the extremity of the plain. We hoped that the branches would split open the balloon and put an end to our furious course. The anchor was broken, and nothing but its ring remained at the end of the rope;—our only hope was thus dashed to pieces.

Holding on to the valve-rope with all his strength, and squatting down at the bottom of the car, Tissandier pulled away lustily, whilst the *Swallow* jumped about from one tree to the other. The branches of the trees bent beneath the car, the wind whistled in our ears; the balloon appeared to have lost some gas, but a sudden gust carried it from the wood again, and down it came with a hard bump upon the open plain beyond. The wind now hollowed the balloon into a kind of cup, or basin, and carried us vigorously across the ploughed land, until finally some men ran up and caught hold of the guide-rope.

We get out of the car, not without difficulty. Tissandier is covered with bruises and more or less stunned. Fonvielle, besides his wound on the head, has his foot sprained, and can scarcely stand. We inquire where we are, and the peasants inform us that we have landed at Neuilly St. Front, which is about forty-eight miles from Paris as the crow flies, and about fifty-one by railway. We look at our watches with astonishment. It is only thirty-five minutes since we left the gasworks in Paris! We have therefore travelled at the rate of ninety miles per hour! No balloon ever rushed through the air with such rapidity as this.

Tissandier emptied the balloon, folded it up, and packed it into the car; the whole was safely deposited upon a cart which had been sent for, and we proceeded toward the village, escorted by a considerable crowd of country people. The cart loaded with the *Swallow* headed the procession; we followed close behind. Fonvielle could hardly walk; he was obliged to lean on the shoulder of his companion, and take the arm of one of the peasants. The crowd got greater as we proceeded.

At Neuilly St. Front we were received by the mayor, M. Charpentier, with the greatest kindness; and whilst a medical man examined the extent of Fonvielle's wounds, we gave an account of our rough adventure. We were anxious to see what distance we had been pushed along the ground by the wind, so returned with some of our new

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companions to the fields. The traces of our bumping and dragging were perfectly visible, and we saw the summits of the trees that had been broken in our furious course. The country people said that they saw us playing at leap-frog over these oaks some twenty yards high, and that they were astonished at the rate at which we were going—much quicker than an express train, they said. This must have been the case, for our furious gallop only lasted five minutes!

In this excursion, though so rapid and so rough, we were able to note a very exceptional degree of temperature, and a no less exceptional velocity of wind. As Fonvielle's accident took longer than we imagined it would to get cured, and as I was anxious to verify this case of extraordinary mildness of temperature, I begged Messrs. Cassé and Delahogues to observe the temperature in an ascent they made very shortly afterwards. They found a temperature of 60°·8 Fahr. at an altitude of 3,281 feet, whilst the ground below was almost frozen. They thus confirmed the result obtained in our previous excursion.

A fortnight later we were about to make another ascent, but gave up our place in the car to our artist, M. Albert Tissandier, in order that he might be better able to illustrate the present volume. Unfortunately, this ascent, which he was to make with one of his friends, M. Moreau, was not a lucky one.

An unforeseen accident brought to a premature end this expedition, which seemed destined to have been so successful; for the sun shone gloriously forth, the weather was clear, and the wind, though it blew in slight gusts, was not very strong.

Just as M. Mangin, the pilot, gave orders to let go, the balloon was blown against a part of the gasworks. M. Webber, in trying to hold it back, was thrown down, had his wrist sprained, and his head cut. The persons in the car immediately threw out two bags of ballast, but it was too late; the balloon was driven with great force against one of the gasometers, to which its netting got caught and the envelope torn open. In a few moments it came heavily to the ground.

All this happened in less than a minute, and the crowd which had accumulated to witness the balloon rise, had the unexpected spectacle of a *descent* presented to them.

The balloon was split open from the neck to the valve, but its reparation was neither long nor expensive. The only material loss was that of the gas; upwards of 30,000 cubic feet of which had escaped into the air in less than one second!

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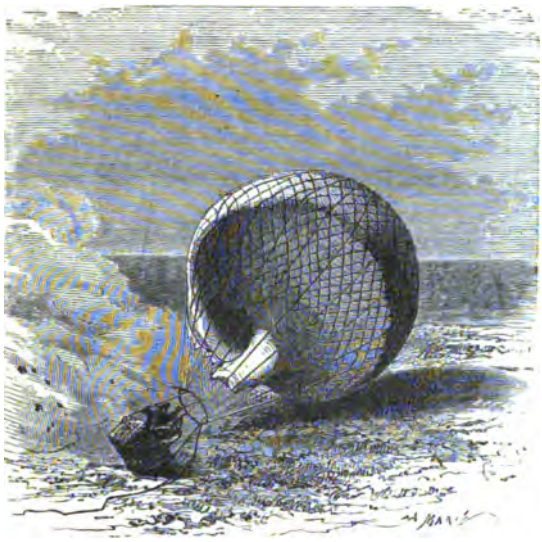

DRAGGING (SEE CHAPTER VII.)

CHAPTER VIII.

TWO HOURS OVER PARIS IN A CALM.

(W. DE FONVIELLE AND G. TISSANDIER.)

On the 25th of August, 1783, when the first balloon inflated with hydrogen gas rose from the Champ de Mars, some astronomers placed at different places in Paris followed its course through the air, and each observer took the angle of the balloon by means of a theodolite, as they would have done for a meteor. The sky was cloudy, however, so that few measures could be made: nevertheless, Meusnier, a distinguished artillery officer, was able by this means to trace the track of the balloon through the air. A month later a fire balloon was sent up at Versailles in the presence of Louis XVI., and was also observed by two astronomers, one on the high terrace of the Observatory, and the other on the ground-floor: Meusnier was again able to define the course of this balloon by the aid of the figures thus obtained.

But since Pilâtre de Rozier and the Marquis d'Arlandes made the first balloon ascent, and showed that human beings could travel in the air, these kinds of observations have been abandoned. Not-

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withstanding this, it is certain that observations made by the aëronauts themselves would complete and control those made on the ground. The exact determination of the course of the balloon would verify the accuracy of the instruments employed by them, and by which they determine their height every moment; whilst the observations made by astronomers would also be confirmed.

What an excellent opportunity we have in a balloon ascent for determining the laws of atmospheric refraction, the accuracy of micrometric measurements, the appreciation of apparent diameters, &c.! A portion of these considerations was brought by one of us before the Congress of learned societies at its recent meeting, when M. Le Verrier did us the honour to endorse our conclusions, and gave us several pieces of valuable advice, by which we hope soon to profit.

No one could deny, we imagine, the interest which such an order of researches presents. Nevertheless, certain persons who hold a distinguished position among meteorologists and astronomers have observed that they feared balloons disappeared too quickly to enable any one to take their measurement with any precision; and that it was not probable that the older astronomers would have given up these kinds of experiments had they been convinced that any value attached to them.

We replied to these remarks by referring to the fact that Mr. Glaisher had observed the balloon of Mr. John Welsh during its entire course from Vauxhall to Folkestone, a distance of nearly sixty miles. Moreover, we determined to reply still further to these criticisms by making an experiment which should leave no doubt upon the subject. We determined upon causing our balloon to remain quite still, or nearly so, in order that the whole of Paris might see it as a stationary object in the air. Such a result required not only a clear day, but the complete absence of wind, or the simultaneous existence of a series of small currents at different heights.

We have been fortunate enough to float for a long time just above our starting-point, so as to be visible from below for two whole hours.

We intended starting on the 4th April in the *Union* balloon, and M. Le Verrier had invited some members of the scientific Congress to witness our ascent; but the weather proved bad, and the rain came down in abundance, so that we were obliged to put off our ascent till the Sunday following. We were thus deprived of the benefit that would have resulted from the presence of several

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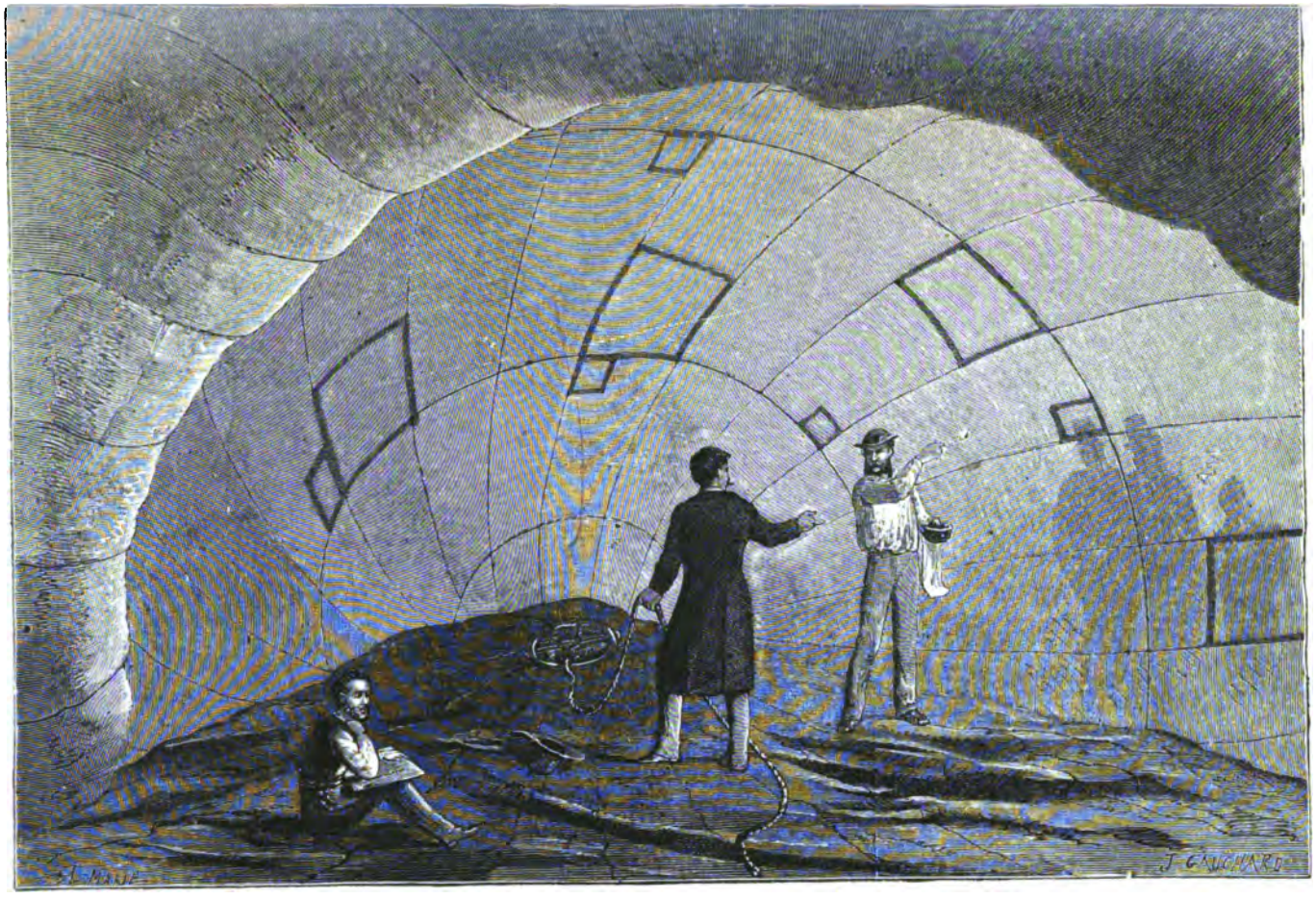

INTERIOR OF THE "UNION" BALLOON INFLATED WITH AIR.

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distinguished physicists who were prepared to have made certain observations on this occasion.

Eight days later we decided on starting, whatever might be the state of the weather, and we determined to inspect the interior of the balloon ourselves; it was therefore inflated with air, and we went in early in the morning to see if there were any holes in the tissue that required mending. We might make such an examination with the aid of a powerful lens. However ridiculous this may appear, the result would doubtless be beneficial; for gas can escape by holes that are quite invisible to the naked eye.

The *Union* aërostat is spread upon the grass, and a ventilating fan fixed to the neck of it. Two workmen turn the fan, and as the air enters the balloon swells up over the ground. Mangin and I penetrate into its interior, and find that the temperature inside is quite suffocating, being no less than 91°·4 Fahr., whilst outside it was only 77°·0. This fact need not surprise any one; for a semi-transparent stuff like that of the balloon acts like the glass of a conservatory: it allows the luminous rays of the sun to penetrate through it, and stores up the heat. The interior of the air-inflated balloon presents a somewhat singular aspect: we find ourselves in an immense dome which the motion of the air causes to oscillate to and fro; the light which filters through from outside is soft and uniform. The shadow of persons outside is projected on to the balloon, and, from the interior, is seen like "Chinese shadows." Altogether the spectacle is too curious to describe accurately, so M. Albert Tissandier comes in with paper and pencil to make a sketch of it.

Next day, 11th April, the weather appeared to be very fine. Since last evening the barometer had been remarkably steady, and in the last few days the higher clouds had not taken the form of threatening stripes like those which Turner reproduces so excellently in his agitated skies, and which, according to our own personal experience, generally seem to announce bad weather.

Whilst the balloon was being inflated we noticed that the sky was dark blue. Early in the morning we tried the state of the atmosphere by sending up a small and elegant captive balloon of some 600 cubic feet capacity, constructed with great care by M. Duruof.

The process of inflating proceeded much slower than usual. Though the gas flowed into the tube at the ordinary pressure, it did not enter the balloon with the calculated velocity. We knew that the valve had got warped since the *Union* was last used, but we had remedied that by pressing the sides together and adding some supplementary

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springs to keep it closed; moreover we had applied a thick layer of grease over the valve. Surely, we thought, this would retain the gas. And so it did, for the cause of the tardy inflation was discovered to be a small piece of cloth, which in some unaccountable manner had forced its way over the orifice of the tube which led the gas into the balloon, thereby diminishing the size of this orifice considerably, and fully explaining the slowness with which the inflation proceeded.

This unfortunate circumstance caused a delay of two hours, much to our annoyance, for some gentlemen connected with the Zurich Observatory had come to witness the ascent.

Whilst the last remaining fissures were being carefully stopped, Fonvielle erected a kind of rudimentary observatory upon the ground. It consisted of a telescope upon a wooden stand, provided with a vertical graduated rod, whilst upon the sand around it he had traced a wind-rose. This apparatus was destined to follow the various directions taken by the balloon.

We could have wished that the telescope had been provided with a micrometer, in order to measure the apparent diameter of the balloon at various intervals: but our principal object was to prove that the aërostat could remain in sight for a considerable space of time.

When all was ready we got into the car, and our pilot, M. Mangin, adopted a simple and prudent method of starting. He held one extremity of a rope, the other end of which was held by five or six of his friends on the ground, and by letting it go the rope falls, and we soar up very quietly. A single bag of ballast then thrown out causes us to rise quite as rapidly as a vulture would fly.

The sun shone forth, and the network of the balloon puffed out under the influence of its warm rays. The flags hang down in elegant festoons, and seemed to follow us with some difficulty. If the valve had been perfectly tight without the poultice, we could stay our upward course at any moment by letting out a bubble of gas; but in its actual state it would have been imprudent to touch it; therefore, we allowed the valve-rope to remain dangling idly in the car, and reckoned upon the escape of gas from the neck, and the constant loss through the pores of the balloon, to prevent our soaring into unknown regions.

We were not long in perceiving that the object of our excursion was fulfilled to the utmost extent of our expectations. The sur-

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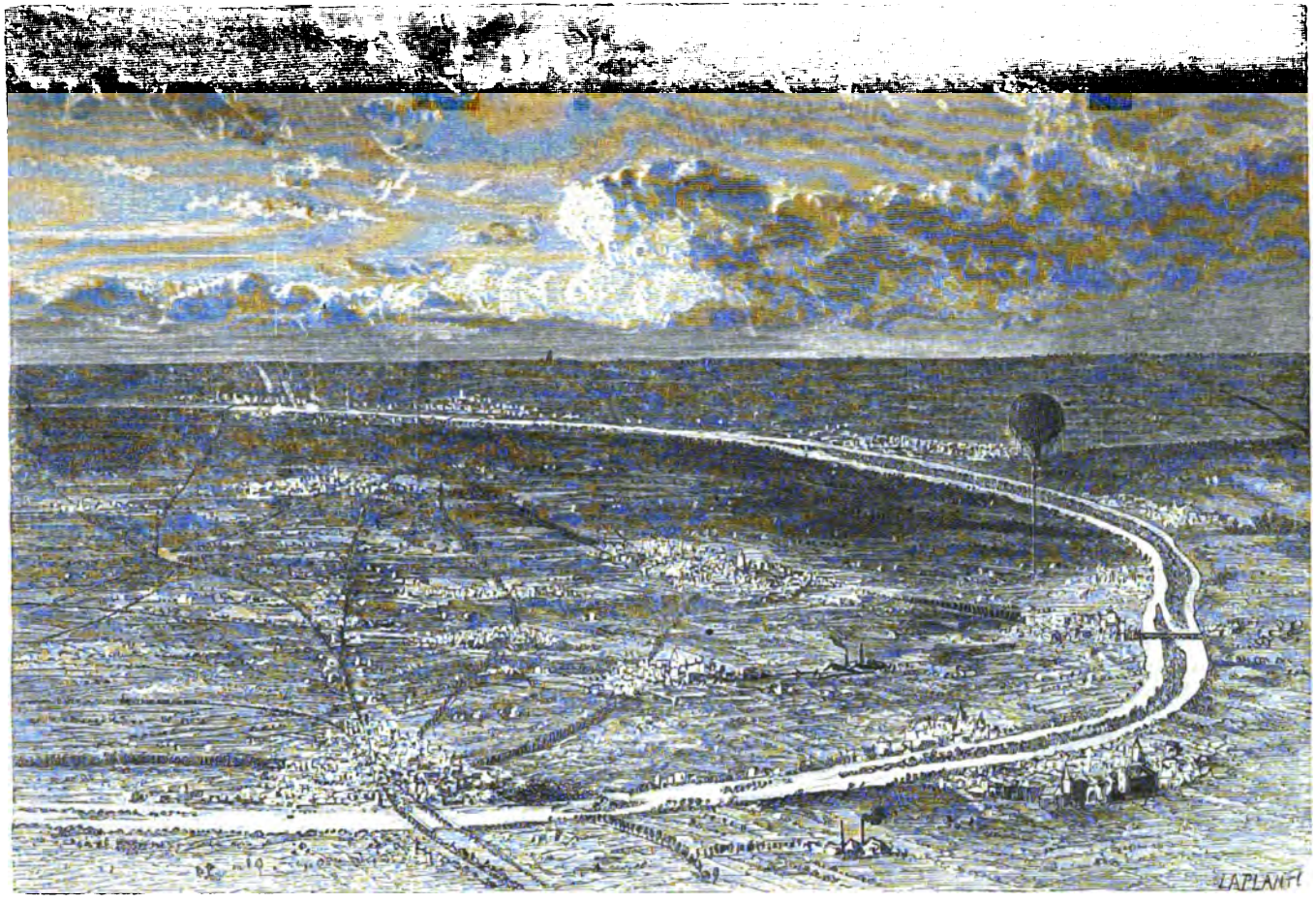

THE SEINE AS SEEN FROM THE BALLOON ABOVE ASNIÈRES.

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rounding objects appeared perfectly still; the motions of the balloon from right to left, or from north to south, compensated each other most accurately. We rose and sank alternately, or we veered off a little and came back again directly; constantly hovering over the spot where the aërostat was filled with gas a little time before.

During this time we amused ourselves by noticing the fluctuations of the aneroid needle as we rose or sank a little by intervals; it was interesting to witness how accurately it obeyed the hand that poured out a little sand. We were surprised also to meet with a floating spider's thread of gossamer; Fonvielle stretched out his hand and caught it. Here we had an aërostat manufactured by a minute field-spider that abandons itself in its frail skiff to the mercy of the winds! On some other occasion, when we shall bring up a microscope into these higher regions of the air, which we thought to be completely deserted, perhaps we may discover a whole world of minute beings of which this is only one example.

The scene below was so beautiful, that while contemplating it we quite forget the danger that was threatening us,—namely, that of coming down in one of the Paris streets! The country around was beautifully green, and the Seine flowed through the landscape like a brilliantly-coloured scarf. Argenteuil lay on the horizon, and immediately below us was Asnières; we saw the rowers in their boats upon the river, but from such an elevation they seemed quite still, though they were ploughing the water with all their power. On the other side of the landscape Paris was spread out beneath our eyes.

We notice around the horizon and extending to the height of our car, a kind of circular mist, and over the summit of this semi-translucent well of fog, of which our aërostat forms the centre, soar a string of little pearly clouds, white as silver, and of very elegant forms.

At first we rose to 5,200 feet, but now we have reached a height of 6,400 feet, and the heat is very great, 75°·2 Fahr. We are so still that we might imagine ourselves bound to the earth by a thousand invisible ropes. By means of my telescope I can distinguish every quarter of Paris, the riders in the Bois, the loungers in the Tuileries, the churches, the monuments, and the very streets in which we live.

Generally speaking, the earth, seen from the balloon, appears flat;

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but to-day the country around certainly presents a few undulations, an effect which may be owing, perhaps, to the different quantities of light which the various surfaces receive according to the slope which they present to the sun. As to the shadow of the balloon upon which we reckoned for making some experiments, it is quite impossible to find out where it is. This fact is not to be attributed, I think, to our altitude, so much as to our perfect immobility. When a balloon travels along, the shadow is soon recognized, even from a great height, as a black spot, often very small, which glides across the fields and houses with great rapidity, and is easy to distinguish from anything else by this rapid motion.

We were, then, in the same predicament as the hero of Chamisso, who had lost his shadow, when a curious observation caused us to cease looking for it. Whilst the balloon gradually sank towards the earth, a confused kind of murmur reached our ears: it was not unlike the distant breaking of waves against a sandy coast, and scarcely less monotonous. It was the noise of Paris that reached us as soon as we sank to within 2,600 feet of the ground, but which disappeared at once when we threw out just sufficient ballast to rise above that altitude. What an ocean of thought and rumour was there beneath our feet!

Whilst we were talking of this, Mangin let the anchor slip out. Unfortunately he did not take the precaution which I recommended, and hang it sideways, by means of a piece of string, so that it did not run the risk of fixing itself in some housetop—for such threatening shoals were rampant in all directions. We endeavoured to avoid the consequence of this omission, and to get the anchors back again, but it was too late; the attempt caused the car to oscillate considerably, and this might have become dangerous, for the balloon was an old one.

We must, then, navigate how we can, and not attempt to take in the anchor, and so our situation has become rather precarious. If we could maintain ourselves at a given horizontal height, we might profit by the light breeze and allow it to carry us away into the country. But we have expended three sacks of ballast in an hour, and we cannot expect to keep the balloon at the height of 4,900 feet, with the only sack that remains on board; and to preserve a horizontal course will cost us more than we can afford to enable us to float over the whole city of Paris. We prefer, therefore, to continue our alternate rising and sinking, coming nearer and nearer to the ground.

We hold a short consultation as to the government of the balloon

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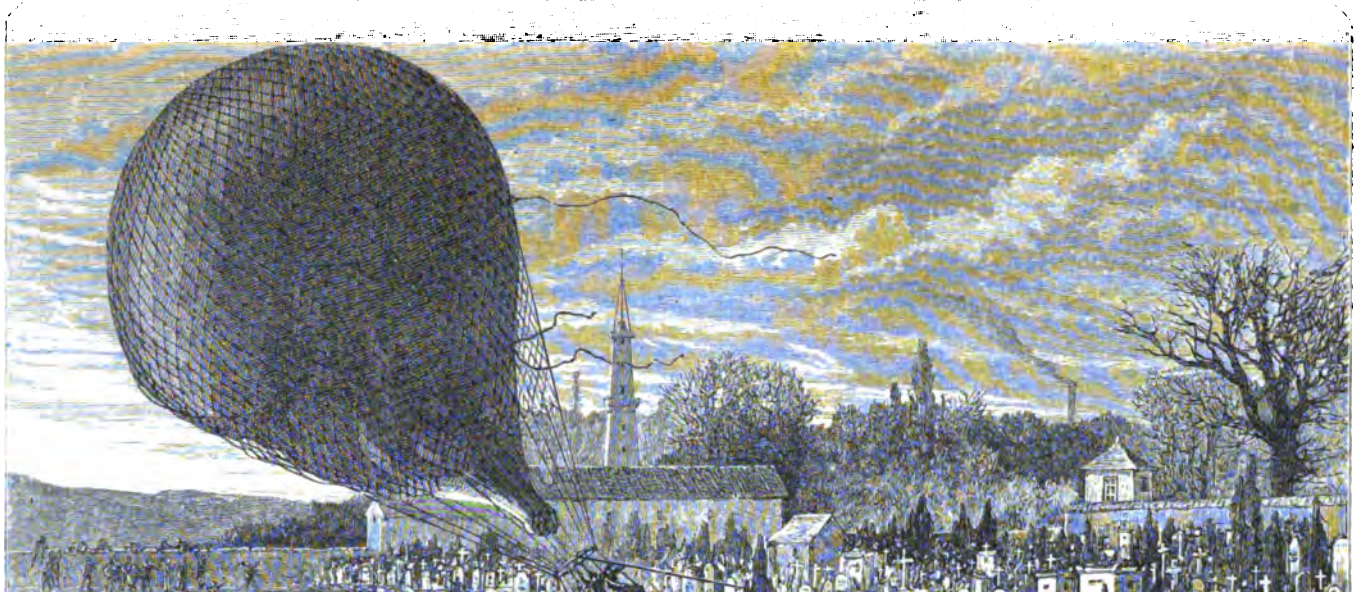

DESCENT OF THE "UNION" BALLOON IN THE CEMETERY OF CLICHY.

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during the descent. As our guide-rope is longer than that of the anchor, our safety will depend principally upon it.

The multitude of people in the streets, whose clamour rises to us so distinctly, cannot fail to furnish a few willing hands to help us, and direct our course when we come close to the ground. If we are lucky enough to come over a clear space, we will open the valve at once, and if necessary throw out a little ballast to diminish the force of the shock, which might otherwise compromise our lower extremities. About twenty minutes to five o'clock a lower current of air carries us along with tolerable rapidity in a direction parallel to the fortifications. We pass over the goods railway station at Batignolles, and we perceive a cemetery beneath us. In front we have the St. Lazare Railway, with quantities of engines, whilst to the right and left are numerous houses and some small works. It is the Clichy Cemetery that is just below us, and the only spot where we can effect a tolerably secure descent.

We did not deliberate long, and in spite of M. Mangin I pulled the valve-rope, and brought the balloon down. A crowd of crows flew off as we approached, and the tombstones stood out in a most picturesque fashion as we neared the ground; the sight of the balloon was too much for a poor woman who happened to be there; she uttered a shriek and rushed off, carrying her child with her.

Our anchor caught in a newly-opened grave; some men ran up and caught hold of the guide-rope, and we reached the ground with remarkable quietness.

In our last excursion we had travelled fifty miles in thirty-five minutes; at the rate we had been going in this one, we should have required about five days to perform the same distance. In fact, the aërial ocean has its tempests like the North Sea, and its dead calms like that of the tropics.

My brother Albert, who from the heights of Montmartre had witnessed our ascent, had time to come on foot to the spot where we descended. In fact, he might easily have walked about four times as quick as our balloon travelled.

M. Wolf, the director of the Zurich Observatory, caused some meteorological observations to be made at different altitudes on the day of our ascent. The temperatures observed by him are considerably lower than those we registered at corresponding altitudes. This may appear a detail of little importance, but to us it is not so. Probably the glaciers of the Swiss mountains have their influence

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upon the temperature of the aërial ocean above them, which is like ice as compared to our Parisian sky. Moreover, the influence of the Alpine ranges made itself felt also in the astonishing variety in the direction of the wind. At Zurich the wind was east and strong; at Berne, S.W., slight; at Castagna, S.W., very mild; at Sainte-Croix, N.W., weak; at Closter, S.E., weak; at Beners, S., weak; at Duber, E.; at Chaumont, E., weak; at Neuchâtel, S.W., weak. At several of these stations thunder and lightening were noted, and in the Alps a storm with high wind. At Sainte-Croix heavy clouds floated above the horizon, and rain fell in torrents. At Berne, thunder was heard. Who can have any doubt but that the Alps were the cause of all these perturbations? Without the presence of these mountains, the sky of Switzerland might have been as calm as that in which the *Union* balloon appeared to have cast its anchor.

The above observations noted by M. Wolf, whom we thank for the interest he takes in our experiments, appear to us to point to the influence exerted by high mountains upon the state of the atmosphere in adjacent countries. Whilst our balloon was fixed in the air above Paris in a state of perfect tranquillity, thunder roared and impetuous winds blew over Switzerland. Would not the science of meteorology, or rather the "science of the air," make rapid progress if such experiments were more frequently carried out—or if comparative ascents were made frequently in a great number of localities? We could thus follow the course of the various currents at different altitudes, and the results would, doubtless, be fruitful.

What should we know of the ocean if a few sailors only had navigated a short distance from the coasts, without losing sight of port? Should we ever have had any notion of the vast currents that flow regularly from the poles to the equator, and reciprocally counterbalancing the heat of the one and the cold of the other? Should we ever have become acquainted with those vast fields of seaweed, those shoals of madrepora, or the regions of calm? Where would now have been the bases of the physical geography of the sea? The same argument applies to the gaseous ocean in the depths in which we live. Now that the telegraph has united all the nations of the earth, why do we not at once undertake simultaneous balloon ascents at given periods of the year—why should we not explore those higher regions systematically, and endeavour to discover the tides of the air?

In our last ascent but one we rose into a heated current, the existence of which was not suspected by those on the earth's surface. Where did this warm river, which flowed for a whole

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month over the clouds, arise? Where did it derive its heat? Did it come from the tropics? And why is the air so calm and stagnant to-day, like the tranquil water of an inland lake? What numbers of grand and useful problems arise when we think of the possible results of systematic balloon ascents!

INFLATION OF THE BALLOON WITH A VENTILATOR.

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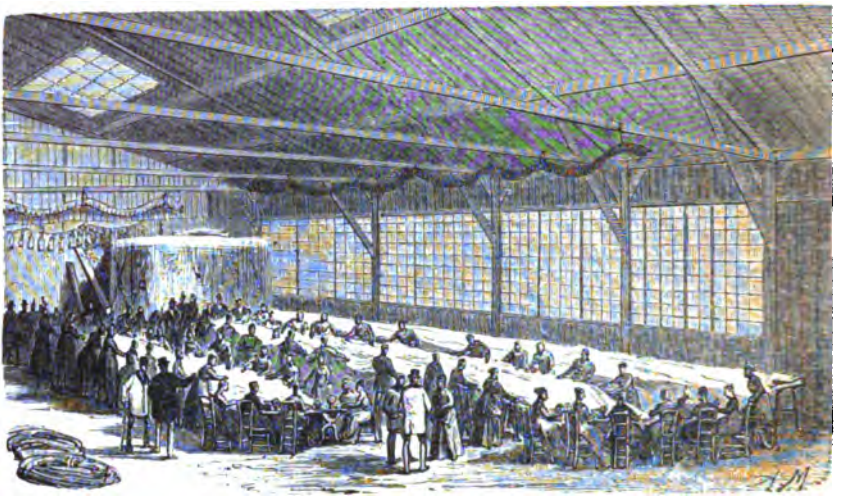

CONSTRUCTION OF THE "CAPTIVE" BALLOON OF LONDON.

CHAPTER IX.

THE GREAT "CAPTIVE" BALLOON AT LONDON.

(W. DE FONVIELLE AND G. TISSANDIER.)

THE great *Captive* balloon was located at Chelsea, in a circular enclosure formed of linen upon a wooden frame extending to the height of a five-storied house, and representing an immense cylinder 575 feet in diameter. In the centre of this circular space stood the vast aërostat, the volume of which, being no less than 424,000 cubic feet, was greater than that of an ordinary gasometer, and its height 121 feet. The *Captive* was suspended over a circular opening, at the bottom of which was an iron pulley for the cable to run under. Some hundred ropes fixed to the equatorial band of the balloon and to the circular enclosure helped to hold it down when not in use.

The cable was 2,132 feet long, and weighed 59 cwt.; it was proved to be capable of bearing a tension of twenty tons.

This cable was attached to the balloon in a very ingenious manner, and connected with a machine for determining the tension on the cable, as shown in Fig. 1, next page.

In Fig. 2 is shown how the rope passed under the iron pulley at the bottom of the circular opening; thence it ran through a short subterranean tunnel to an immense cylinder or reel, moved

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by steam. This reel was twenty-three feet long and six and a half feet in diameter; the rope wound round it 100 times. Two steam-

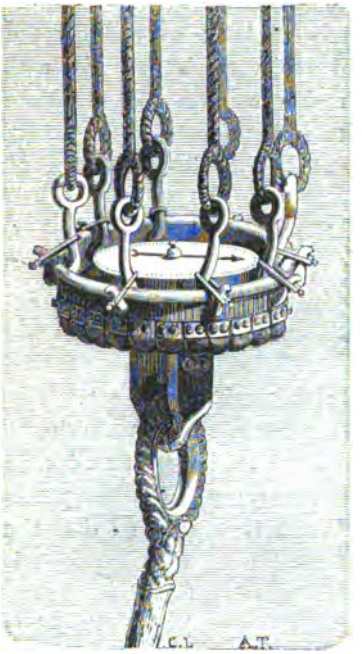

FIG. 1. THE WEIGHING MACHINE OF THE "CAPTIVE."

engines of 150-horse power were employed to put this apparatus in motion.

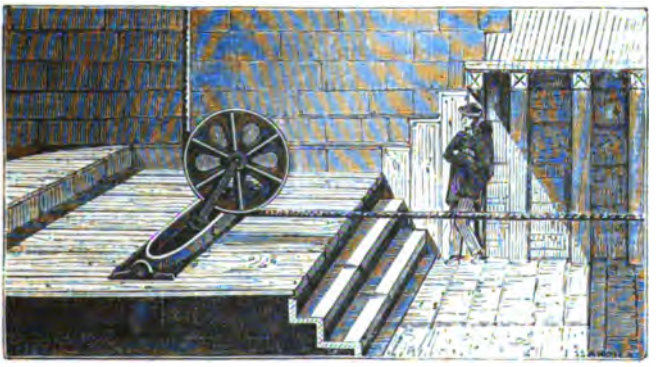

FIG. 2. THE PULLEY.

The *Captive* balloon was inflated with pure hydrogen gas; and one of the greatest difficulties which M. Giffard had to contend with

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was to render the stuff of the balloon impermeable. The tissue was formed of several layers of stuff: first, a layer of india-rubber was enclosed between two sheets of linen, and this again covered with a second layer of india-rubber; over this came a layer of muslin, and then a layer of lac varnish and six successive coats of oil varnish. Thanks to this complicated structure of the envelope, the *Captive* was quite impermeable to the enclosed gas, and on the day of its first ascent it had been inflated already for a whole fortnight.

The stuff of the *Captive* balloon weighed no less than 2 tons 15 cwt.; its surface measured 3,000 square yards, and to join all the pieces of tissue together 2½ miles of sewing had to be done. This marvellous aërostat was to other balloons what the *Great Eastern* is to ordinary ships.

On Monday, the 3rd May, 1869, we attended the inauguration of this immense aërial apparatus. At one o'clock precisely the equatorial ropes were let go, the engine set to work, and the large balloon rose slowly into the air, carrying up its heavy cable and about 30 cwt. of ballast besides. When it was found that the machinery worked properly, the bags of sand were withdrawn, and twenty-eight aërial travellers, among whom was Mr. Glaisher, the director of the Meteorological Observatory at Greenwich, substituted for the ballast. We rose with a velocity of 328 feet per minute, and floated at a height of nearly 2,000 feet above the enclosure below. The wind was not strong, and we remained quietly suspended in the air. The atmosphere was foggy, but still we could see the ground, the crowd of spectators, and the river Thames winding below us.

Another ascent was made on the following Wednesday, the 5th of May. The editors of several London papers were invited to inspect the balloon on this occasion, and in spite of the strong wind, blowing at the rate of sixty miles an hour, the *Captive* rose twice very successfully. We were twenty-nine persons in the car, and Mr. Glaisher had his young son with him—a proof of his confidence in the machinery of M. Giffard. The strong wind whistled through the ropes, the balloon lay over, and the car oscillated violently; we were blown about 660 feet beyond the boundary of the enclosure below. However, the strong cable brought us safely back again.

Mr. Glaisher appeared to pay no attention to the wind, or to the oscillations of the balloon: his eyes remained fixed either upon his instruments or the dynamometer, which indicated a tension of three tons, therefore nothing to alarm us, since the cable could bear four times as much.

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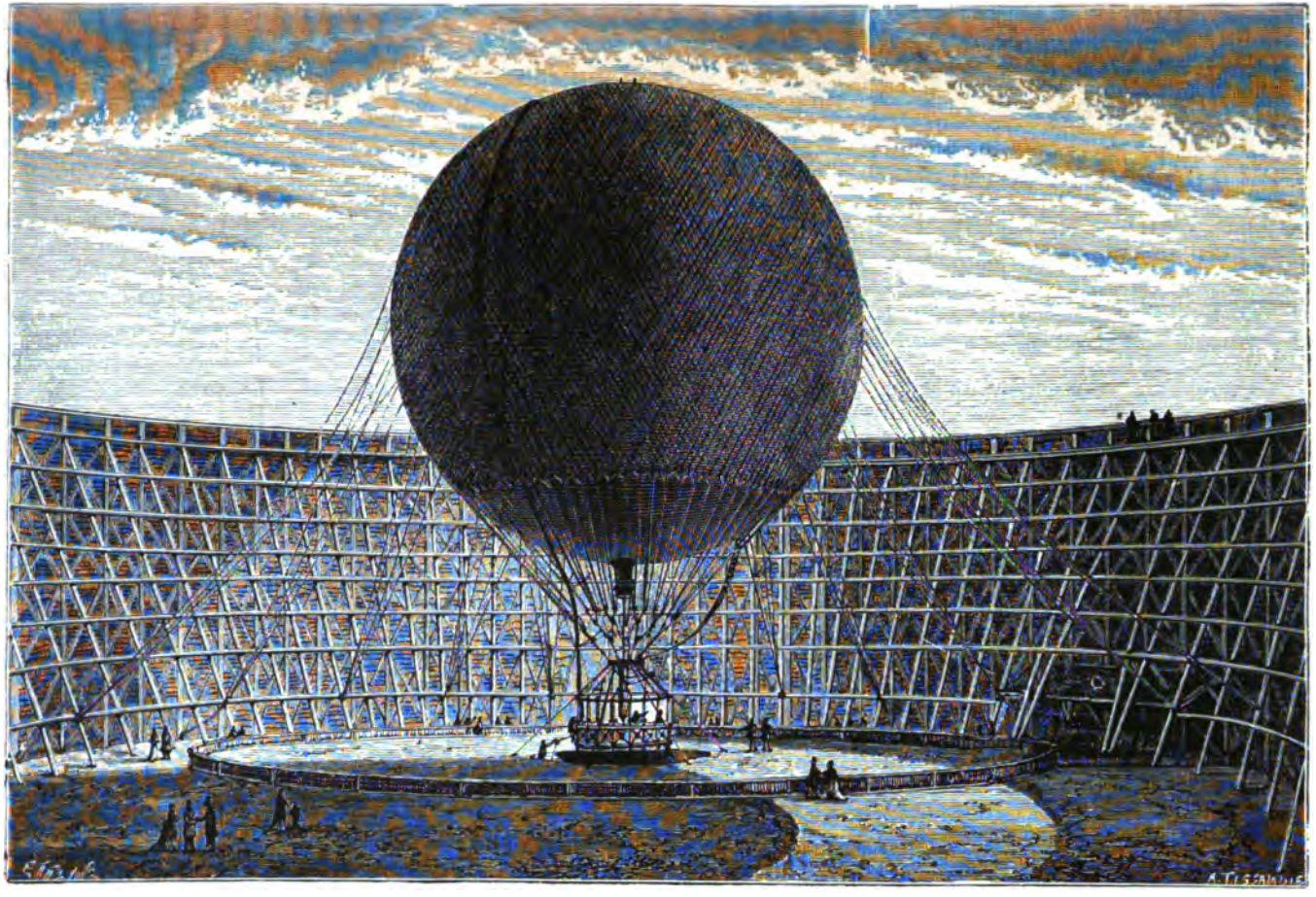

VIEW OF THE "CAPTIVE" BALLOON AT LONDON.

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A SUNSET AS SEEN FROM THE BALLOON

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The sky presented an admirable aspect. The sun appeared in the midst of mountains of cloud, and its brilliant rays transformed the Thames into a river of fire. Houses, trees, and streets appeared no larger than children's toys, and the general aspect of things was the same as we experience in ordinary balloon ascents. In some of our aërial excursions we have risen to a height of 9,843 feet, and the landscape seen from this altitude is not more striking than from the car of the *Captive* balloon.

During this ascent Mr. Glaisher made notes of the temperature and the dew-point, and explained to us in detail his methods of taking observations in the balloon.

The conditions under which a captive ascent is made are, however, very different from those of ordinary balloon ascents, more especially as regards wind. An aëronaut is not accustomed to feel any wind, whereas in the captive balloon it often appears very violent, or even tempestuous. It is like being at sea in a gale, and the car, like the boat of a fisherman, bounds over the invisible waves of the aërial ocean.

From a financial point of view the *Captive* balloon was a complete failure, but in a technical sense it was a great success.

The surface of the earth was dark and dreary when we made our next ascent in the *Captive*. In the car were also Mr. Glaisher and M. Albert Tissandier, who had not forgotten his pencils. We rose through the dark fog which then hung over the great city, and we got a glimpse of the sun darting its gilded rays among those masses of grey cloud or mist, and again lighting up the water of the Thames, which glistened like a brilliant serpent creeping below thick folds of muslin. The wind was rather violent, and blew in a perfect gale through the ropes and network. We felt cold; the wind nearly carried our hats and our rugs away, so that, like the traveller described by La Fontaine, we were obliged to struggle against the efforts of the god Boreas. We remained for a quarter of an hour in presence of the magic spectacle, and endeavoured to get a sight of the great capital; but it had disappeared entirely behind its vapoury exhalations. Soon the cable was wound again round the cylinder by the powerful engines, and the *Captive*, like a docile slave, landed us safely on the ground.

The captive balloon is not only an apparatus destined to make pleasant excursions into cloudland; it may be used with considerable advantage for making very interesting scientific observations: for instance, to measure the intensity and direction of the various currents of wind; to ascertain daily the exact hygrometrical state

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of the air, and the temperature of the atmosphere at different altitudes. Thus it may some day become a powerful agent in accelerating the progress of that young science termed meteorology. When the Aurora Borealis glimmers in the heavens, the captive balloon can carry the observer above the clouds, and bring him face to face with that imposing phenomenon. When the shooting stars dart across the sky, the astronomer might leap into its car, and rise into a region where observation will produce fruitful results. In fact, we have no doubt that captive aërostats will play an important part in developing the science of the atmosphere.

In spite of the charm attaching to aërial travels in general, the English public did not think proper to patronize the *Captive* balloon of Ashburnham Park. It was decided, therefore, that on the 13th May, several journalists should be invited to make an ascent at two o'clock, and partake of luncheon in the air; and a very joyous ascent was made on that day with about twenty persons in the car. However, just as the *Captive* appeared to be getting over its difficulties, an accident put a sudden stop to the speculation.

On Friday, 28th May, the wind was rather strong, and the engineer was imprudent enough to let out some rope at a moment when he thought the car would be blown against the circular enclosure. At this instant the car was, in fact, upon the beams of the enclosure, so that the strain upon the rope slackened, and the latter got out of the pulley. A gust of wind drove the balloon away, and the rope was speedily worn through by intense friction against the metallic sides of the groove. It broke! and the balloon shot up into space with the velocity of a cannon-ball, carrying up a piece of beam at the end of the rope. Luckily there were no persons in the car at the time, and, thanks to the automatic apparatus in the balloon itself, the danger to the latter was considerably diminished.

It is evident that the first bound would have proved somewhat serious to any passenger in the car, but he would have run no further risk than that of being suffocated by the rapidity of the upward flight.

It is supposed that the *Captive* rose in this instance to a height of some 12,000 feet, but in doing so it must have lost a considerable quantity of gas through the safety-valve in the neck. Once in a state of equilibrium, it was not long in coming down, and reached the ground at twenty leagues from London, near Linslow. The piece of cable it had taken up acted as a kind of guide-rope, and the balloon came to a standstill in a plain, after making several high bounds. Some country people ran up and hung on to the ropes,

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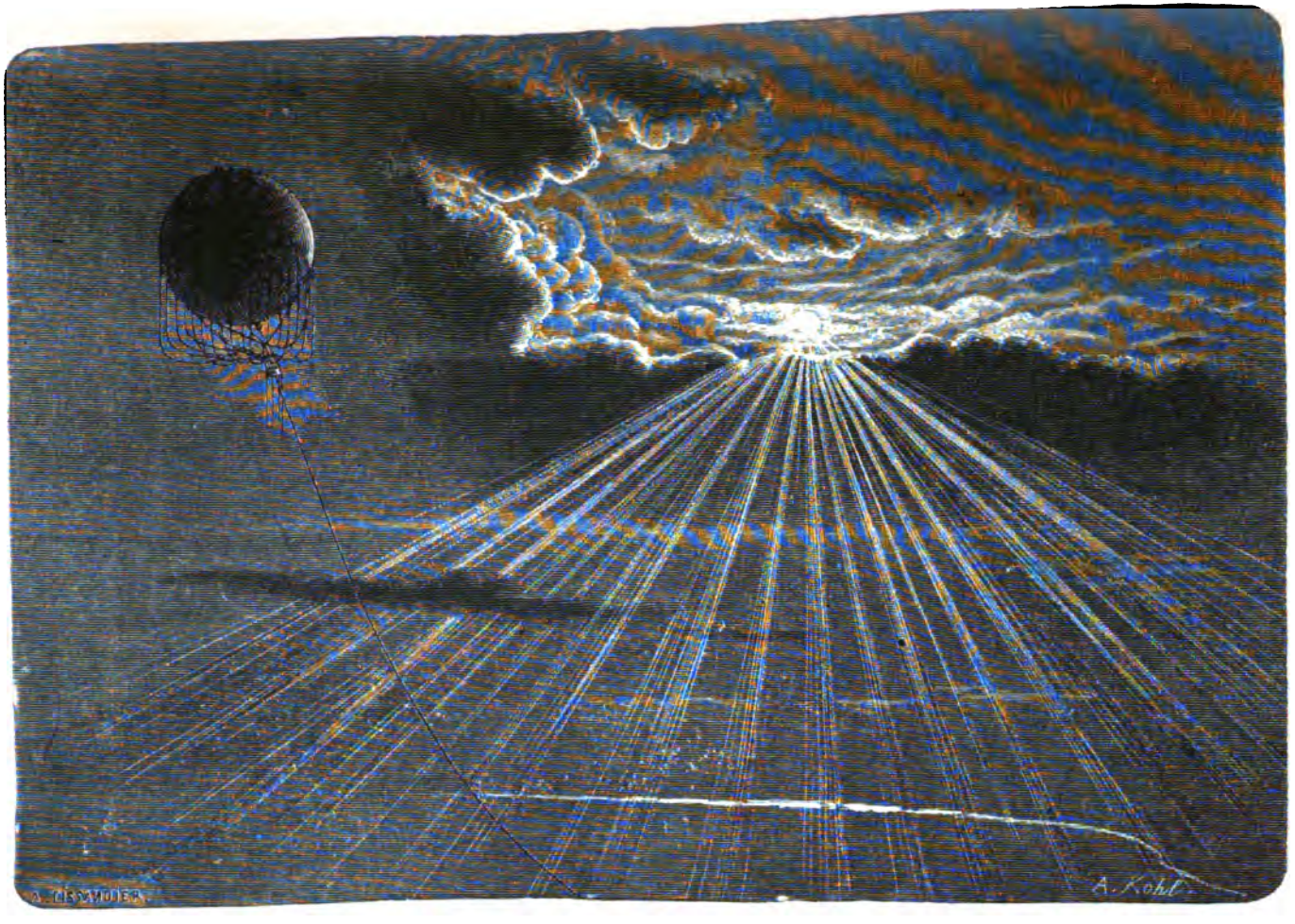

SUNSET ABOVE THE THAMES, AS SEEN FROM THE "CAPTIVE" BALLOON.

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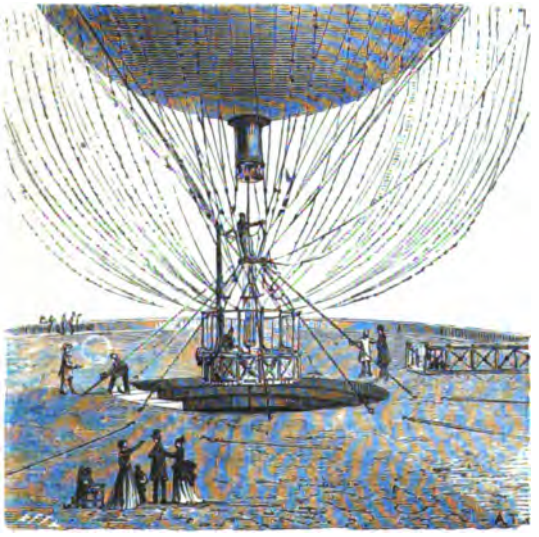
and a lad got into the network. At this moment a gust of wind caused the balloon to rise again to a height of some 130 feet, carrying up the child with it! He was got out when the balloon came down again, but the person who came to his rescue fell to the ground on getting down from the ropes, and broke his shoulder. It was now dark, and one of the inhabitants mounted a horse and rode off for a medical man. On the road his horse ran against a carriage and fell dead on the spot, breaking the leg of its rider in the fall.

The *Captive* had arrested its course at the foot of a large oak-tree on the grounds of Sir Harry Verney. It passed the night under the superintendence of Colonel Pratt, and guarded by fifteen men. Next morning the news of its capture was telegraphed to London.

The last person who went up in the *Captive* balloon was an old woman aged one hundred years; the same who, on losing her son aged seventy-five, exclaimed, "I felt sure I should never bring up that poor child!" For the last forty years she had been an inmate of the Lambeth Workhouse, and on her hundredth birthday, when the master of that establishment asked her what she would like best on this occasion, replied that she longed to make an ascent in the *Captive* balloon. The car was therefore placed at her disposal, and she rose into the air accompanied by some of her ancient friends.



THE CAR OF THE "CAPTIVE" BALLOON

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THE "NORTH POLE" BALLOON IN THE AIR.

CHAPTER X.

AN ASCENT FROM THE CHAMP DE MARS.—THE "NORTH POLE" BALLOON.

(W. DE FONVIELLE AND G. TISSANDIER.)

I. The Preparations.

M. H. Giffard having kindly placed at our disposal one of the largest aërostats ever made, my friend M. de Fonvielle and myself determined to continue our aërial peregrinations in it. But how were we to cover the immense expense of a journey in such a colossal machine? It is evident that we must induce the public to take an interest in it, but as we did not wish to derive any pecuniary benefit, or profit, over and above the expenses incurred, we decided upon naming the balloon the *North Pole*, and handing over any profit that might arise to the Arctic expedition projected by M. Gustave Lambert.

With these intentions I sent a petition to the Emperor, seconded by General Morin, Baron Larrey, and M. Ch. St. Claire-Deville, begging his Majesty to permit the use of the Esplanade des Invalides for making some scientific balloon ascents for the benefit of the French expedition to the North Pole.

I waited one month for an answer. On the 12th of April a letter reached me from the Emperor's cabinet, stating that the esplanade of the Invalides was an inconvenient place for balloon ascents, but

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that if I communicated with the Prefect of Police I should be authorized to use the Champ de Mars.

I wrote to the Prefecture, and I had an interview with the secretary of the Prefect, who kept me waiting one hour in his antechamber. At last I gained admittance, and was informed that the Champ de Mars belonged to the Minister of War, and that I must address myself to him. I hastened to send a despatch to Marshal Niel, and waited anxiously for fourteen days, but no answer came. I then went to the War Office, when I learned that the Minister had been obliged to consult the other military authorities, that they would keep my letter at least a week in their office, besides which the Minister would not give his consent until he had consulted the Director of the Fortifications, who would doubtless wish to consult the Commandant of Paris upon the subject. I was recommended also to pay a visit to the Director of Works on the Champ de Mars, to know if the ground would be ready for the 27th June, for the cavities left by the demolition of the Exhibition building were not yet filled up.

In this manner two whole months rapidly vanished! At last, on the 21st May, 1869, I received a reply from the Minister of War! He informed me that I was authorized to make two ascents from the Champ de Mars, provided I got the consent of the Fortifications Committee, the Artillery Company, the Commandant of Paris, and the Director of Works on the Champ de Mars.

I was thus compelled to hurry from the Rue Bellechase to the Place Vendôme, and from the Place Vendôme to the Champ de Mars, wasting hours of precious time in their various offices, and biting my nails with impatience, day after day.

In the midst of all these embarrassments I learnt that the great *Captive* balloon had arrived from London, and was now at the Port St. Nicholas in Paris. It was the 31st May, and the ascent was fixed to take place on the 27th June. There was, therefore, not a moment to be lost. I rushed off to the Port to get my little packet weighing 9,000 lbs. Alas! I had not reckoned on the custom-house officer!

This acute official politely informed me that as the balloon came from London, nothing proved that it was of French origin; that the india-rubber in it must pay a duty of two pounds per cwt., and the hempen ropes ten shillings per cwt.: the balloon and ropes together weighed nearly three tons! I made use of my most persuasive language to assure him that the balloon was manufactured by M. Flaud, in Paris, and informed him of the absolute necessity of our making the ascent on the day fixed. It was all to no purpose.

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The clerk of the custom-house officer informed me that I must procure a stamped document from the manufacturers, declaring the balloon to be theirs, and duly signed and sealed by them. Without this I must pay the duty, amounting to about 120*l.*!

Fortunately I was able to procure some kind of a document which satisfied the custom-house authorities, after rushing about Paris in a cab for more than three hours; and the next day the balloon was given up.

As soon as we got possession of it we commenced making a large car for it, some nine square yards in surface, and adjusting to it the necessary ropes. M. Giffard, with his usual generosity, not only had everything done at his expense, but actually subscribed handsomely to the fund for the Lambert expedition. The management of our balloon excursion was confided to M. Saint-Félix, formerly a passenger in the *Giant*, when he was crushed by the car in the descent at Hanover, and now exalted to the rank of pilot of the *North Pole*.

The Parisian Gas Company, when made acquainted with the object of our ascents, proved very kind and obliging, allowing us our quantum of gas for the sum of 4,000 francs (160*l.*), instead of 10,000 (400*l.*) Whilst M. Saint-Félix arranged the placards and superintended the enclosure, I took the necessary steps to procure a detachment of soldiers to keep order whilst the balloon was inflated on the day of the ascent.

I addressed myself for this purpose to Marshal Canrobert, but the June disturbances having begun, I was told that the ascent would not take place at all if they continued, and that I must again address myself to the Minister of War.

I was obliged to follow this advice, but could not help trembling when I thought of the numerous difficulties which arose as the decisive moment approached. The great placards already announced the ascent for the 27th June, and there was no possibility of putting it off. What a week Saint-Félix and I passed before the advent of that Sunday which was to mark an epoch in our lives!

The 21st June arrived before I had received any reply from the Minister of War, and the police authorities had refused to send any men unless the military authorities would allow us some soldiers also. In this dilemma I went to General Soumain, the Commandant of Paris. To my astonishment he cut short my discourse, saying that he knew all about it; that the authorities were highly to blame in allowing us to make use of the Champ de Mars, already so long occupied by the Exhibition building, when it was

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required for drilling the troops, and that it was not laid out for the purpose of making balloon ascents. "As for soldiers," he said, "you shall have none; and as for your request for a military band, you shall not have that either. The army is not a police force, and military music was never intended to amuse a parcel of fools!"

In fact, the worthy General allowed his temper to get the better of him, and our interview turned out rather melodramatical. He persisted in his assertion that whatever I might do we should have neither troops nor music on the Champ de Mars.

The Minister of War was at this time with the Emperor at the camp of Châlons, and I need not here enter into the particulars of certain influences which I brought to bear upon our cause, but content myself by stating that two days later I received a letter from him containing the following words:—"By letter of this day I have ordered M. ——— to place at your disposal 200 infantry and 150 artillerymen;" and the day following I received a visit from the amiable bandmaster, who showed me the programme of a delicious concert, the music of which was to be performed during the inflation of the *North Pole* balloon.

The Academy of Sciences was kind enough to take an interest in our ascent, and named a commission, composed of Baron Larrey, General Morin, and M. Ch. St. Claire-Deville, who supplied us with instructions and instruments; and if certain unforeseen accidents had not occurred, we should have duly profited by them—but what is deferred is not lost.

The Montsouris Observatory confided to us some of its finest instruments; and the Meteorological Society of France gave notice to all its various European stations, in order that simultaneous observations might be made by them on the day of our ascent. We have also to thank M. Husson, the eminent director of the Assistance Publique, for his zeal in the cause of the Polar expedition, and General d'Auvergne for the intelligent artillerymen he placed at our disposal. Our colleagues of the press and the Parisian Gas Company also contributed largely to the success of the enterprise.

As for our friend Gustave Lambert and his Polar expedition, we hoped to gain for them a considerable financial result; but, alas! the Parisian public was cold in this respect; it would not give its mite towards the realization of the great project to which he had devoted so many years of his life; and it thus compels him to witness the departure of Arctic expeditions from every other civilized country

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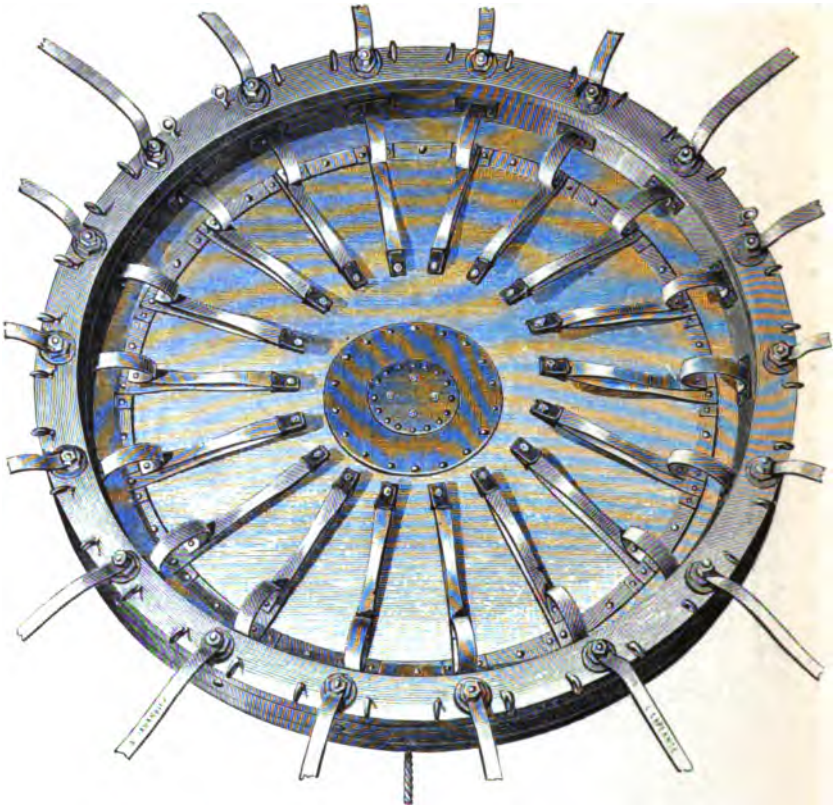
with the view of attaining that Pole upon which he had dreamed of fixing the French flag!

One thought alone consoles us: it is that the Polar expedition and aërial navigation joined hands for once. It was a touching union of two noble causes equally neglected, equally unfortunate.

II. The Voyage.

On Saturday, the 26th of June, the crew of the *North Pole* balloon was on foot at six o'clock in the morning. The aërostat was carried



THE VALVE OF THE "NORTH POLE" BALLOON.

to the Champ de Mars by sixty artillerymen. Its lower extremity was put into communication with the gaspipe, and to its upper part the magnificent new valve of M. Giffard was affixed. This valve is formed of a metallic disc four feet in diameter, which is pressed

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against a wooden hoop by eighteen steel springs. The whole day was passed in making our preparations for departure, hedging in our enclosure, and filling the six hundred sacks of ballast which we required. At nine in the evening we dined with M. Lambert, who volunteered to guard the balloon through the night. We were nine persons in all, ready to ascend the next day.

As stated above, the object of this ascent was a double one; it was to serve the cause of Science, and contribute funds to the Lambert expedition. We must now state, unfortunately, that as far as the financial result was concerned it was a complete failure. There remained a difference, on the wrong side, of 160*l.* between the expenses and the receipts! We hoped to neutralize this by means of a second ascent, but months have since passed, and no further attempt has yet been found possible.

The price of the places had been fixed at twenty francs for the circle around the balloon, one franc for the next circle, and half a franc for the outer one. The first of these might have held about a thousand persons, but many of them had free admittance, and, moreover, the public in the franc places managed to slip into the seats nearer the balloon. As for those who really paid for their seats, they were rare, and one of my friends said it reminded him of the old Latin line, "*Apparent rari nantes in gurgite vasto.*"

The ex-King of Spain and the Prince of Asturias were among the spectators, and the little fellow, thinking himself on the other side of the Pyrenees, no doubt, came and installed himself in the car, and kept back the other children who wished to follow him, until a strong arm was stretched forth and lifted him from his improvised throne.

There were about three thousand spectators in the franc places, and some eight thousand in the half-franc seats. But outside the enclosure there must have been at least 100,000 persons, who stood there for hours together, contemplating with intense interest all the various preparations; and on the Trocadero the multitude was dense indeed. We recognized plenty of rich people, and even several carriages in the crowd there, giving us this hideous proof of their indifference to the success of the Lambert expedition.

The American aëronaut Wells once told me an anecdote which this sight caused me to remember. He had made a very successful ascent at New York, and shortly afterwards met a stranger, who came up and said, "Sir, I was in the street when your balloon passed overhead, and I saw so well that I think I ought to give you the price of one of the first places." Thereupon he placed a two-dollar

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piece in the hand of Mr. Wells, who pocketed the same with considerable satisfaction.

An accident happened to the little balloon, the *Swallow*, which was to accompany the *North Pole* on this occasion. A gust of wind, which had no effect whatever on the latter, caused the *Swallow* to burst suddenly. It sank down immediately, exhaling a few large puffs of yellow smoke. Instead of pitying the aëronaut, who thus lost, in a few seconds, the work of many months, every one was convulsed with a fit of laughter!

Though announced for five o'clock, our ascent did not take place till seven. If we had not been able to rise, the multitude on the Trocadero would certainly have pounced down upon us and torn us to pieces, balloon and all; for nothing can equal the wrath and indignation of those who pay nothing. The cause of our delay deserves to be briefly mentioned.

A balloon, as every one knows, is enclosed in a network of ropes which is firmly attached to the valve. In the *North Pole* this net has 38,000 meshes, and its lower portion finishes with sixty-four ropes. These are united to the hoop to which the car is suspended by means of sixteen much stronger ropes. The sixty-four ropes which hang from the network are each ten feet long, and, together with the eyes at their extremities, weigh, each of them, more than 2 lbs. avoirdupois. Just as we were about to fasten on the hoop, we found that our aëronaut had left the aforesaid sixty-four ropes in his workshop. Tissandier and myself could scarcely contain ourselves on receiving this distressing information. We were obliged to purchase the necessary amount of rope at a shop in the neighbourhood, and the fixing of it, without reckoning the making one hundred and twenty-eight knots, occupied a considerable amount of time.

Sixty-four equatorial ropes enabled three hundred artillerymen to hold the balloon down. The valve, though it weighed about a couple of hundred pounds, was buoyed up as the gas entered the envelope without any help from us. Nevertheless, it was almost seven o'clock, and we had still all our cords, anchor, guide-rope, &c. to arrange. All this work was urgent, for if any accident occurred in the air, and all these matters were not properly arranged before starting, we might consider ourselves as lost. Just at this moment the impatience of the crowd knew no bounds, and we heard the outsiders breaking with a crashing noise into the enclosure. We hastily threw in all our ropes pell-mell, though it might have cost us our lives, and jumped into the car without further delay.

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The frightful disorder that reigned there made us feel very uneasy indeed.

Being in all nine persons instead of eleven as we should have been, Tissandier, who by this time had taken the command upon himself, resolved to take up two more bags of sand; and at a quarter to seven o'clock he gave the order to let go with all the force of his lungs.

It was our intention to pass the night in the atmosphere if circumstances had permitted it; but the lower wind blew in the direction of the sea: we decided therefore to rise, if possible, into another current. We ascended to a height of 10,000 feet with incredible velocity. We then felt a violent wind produced by the motion of the balloon into a contrary current of air: it soon ceased, the course of the aërostat slackened, and we were lucky enough to find ourselves in the higher current, flowing in a contrary direction to the lower one. Fonvielle fixed himself opposite to the barometer and noted its smallest oscillations, two other gentlemen assisted him in making various observations, whilst all the others were actively engaged in arranging the contents of the car.

The *North Pole* must have been a fine sight as seen floating majestically in the air, for it was ten times the size of any ordinary balloon, and much larger than a house of five stories. But we had only risen into the wished-for current by virtue of our accelerated velocity, and to keep ourselves in it we should have had to throw out ballast by sackfuls at a time. We were not rich enough in sand to do this; so, after having floated for a few minutes at this height, we sank and came down into the lower current, which carried us back again in the direction of the sea.

Fonvielle had instructed M. Tournier, one of our companions, to break up the ballast that had got compressed into lumps, lest it should fall to the earth and wound some one; but the latter allowed some to slip from his hands before he was able to break it up. We noticed that it was reduced to dust by its friction against the air in falling, so that it was found quite unnecessary to break it up ourselves.

A portion of our ballast was composed of yellow sand taken in haste, at the last moment, from some of the wine-bins in the neighbourhood. It was very damp, each grain being surrounded by a thin layer of water. When we threw it out, the damp cloud formed by it refracted the solar rays and produced a miniature rainbow, which gradually sank towards the ground.

Our course was directed towards Versailles, and we were not long in passing between the two ponds of Trappes. The sun was already

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near the horizon, and lighted up these two sheets of water with its oblique rays, giving them a golden colour and a most poetical aspect. Soon after the sun plunged into the distant mist, and took a splendid crimson tint, whilst its horizontal diameter appeared considerably enlarged.

After having admired this preliminary spectacle, we witnessed the true astronomical sunset; the optical illusion, by which the width of the sun's disc appeared so much greater than its height, continued to the end. We all remained silent and motionless as we contemplated the grandeur of the display and the striking panorama spread out before our eyes. But these glorious sunsets, as seen from the higher regions of the air, will remain unknown to the generality of mankind, until some Claude Lorraine or some Turner has carried his brushes and palette above the clouds.

When the splendours around had ceased, we turned our attention to the ballast that remained; we had only eighteen bags of it left, and night was fast coming on. To continue our excursion would have been an act of imprudence. We allowed the balloon to sink so gradually that the flags did not show the motion; and this proves what uncertain guides they are to an aëronaut, and how little they indicate the movements of a balloon. It is only when the latter sinks with almost dangerous rapidity that the motion of the flags shows some indication of the descent. With the barometer, on the contrary, it is quite otherwise, and the slightest rise or fall is most delicately pointed out.

A smiling plain was seen beneath us, and Tissandier pulled the valve-rope, but the balloon showed no immediate sign of coming down. Some wooded country advanced towards us and looked menacing: a few sacks of ballast were at once thrown out and re-established the equilibrium. Then another plain appeared as soon as we had got over the woody curtain; it was covered with crops, but we found it necessary to come down notwithstanding, for the guide-ropes had reached the ground and had fastened to something, for we felt them pulling, and the balloon began to bend over.

As soon as the guide-ropes had got clear of the trees among which they appeared to have caught hold, we heard them rustle over the grass as a silk dress might have done, and we could not help listening to this fantastic but melodious *frou-frou*, when we felt a shock, but a much lighter one than we expected to receive. Rarely indeed had this first caress of the earth been so soft with us. It was naturally followed by a rebound of rather more decided a character; and we then held on to the rope and opened the valve as wide as possible.

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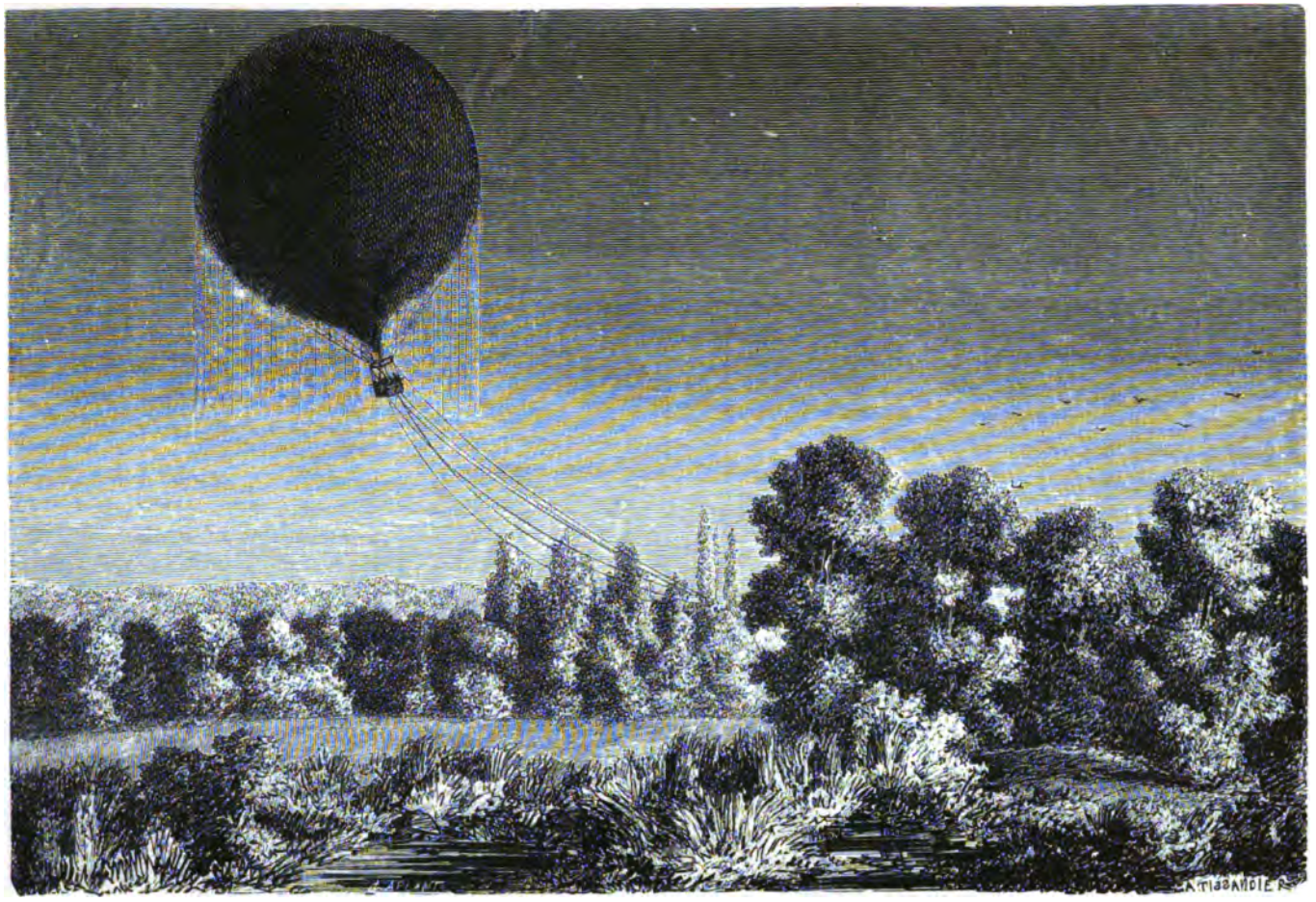

"THE BALLOON BEGAN TO BEND OVER."

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The balloon fell forward, the car bent over, and we began to rub along the ground before a wind which, though it could not be termed strong, was not absolutely wanting in vigour.

The peasants who ran up to assist said that we were going about as fast as a racehorse, and that from time to time we made leaps about thirty yards high. In a small car these bounds and dragging are not very serious, but in the present case six of us were squatted in one corner of the large car, which was bent over to one side, and every minute the feet of two of our companions, pirouetting fantastically among the ropes, came in contact with our heads. We were obliged to hold firmly to the sides of our vast wicker basket not to be thrown out.

However, there is no great danger when the balloon descends upon a well-chosen spot, but it would be interesting, nevertheless, to abridge this portion of the journey as much as possible. And this could be done were the balloon provided with a thread along its entire surface, the withdrawal of which would enable the aëronaut to open the entire envelope at a moment's notice, and thus to let out all the gas at once.

At last some peasants who were stronger and more active than the others, caught hold of our guide-ropes and held on to them with all the strength of their country muscles. We passed the valve-rope to them, for our arms were so tired that we pulled only as a mere matter of form, producing little or no effect. This allowed us to slip out of the car, one by one, and to come down at the side of the ropes. We had descended at Auneau, a village that is not without mark in the history of France. It was the head-quarters of the Duc de Joyeuse, the favourite of Henri III. whom the Bearnoises routed, and the famous duke offered himself a rich reward to the soldier who would take his head. How many balloon descents would be necessary to cause disasters equal to those which civil war gave rise to in this fertile and peaceful district of La Beauce!

We passed the night in keeping guard over the balloon, which we were not able to empty entirely of its gas; and to this effect we made a kind of camp around a haystack. The sky was clear; we had some good telescopes with us, and the moon lighted us up with its silver beams. Our bags were full of provisions, and the greater part of the night passed off very gaily. But we were very tired, and after supper we slept well upon the soft hay, with the exception of two of our companions, Messrs. Sonrel and Tournier, who remained up and studied the lunar disc through the telescopes. We

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had only one regret—that of not being able to pass the night up in the air.

An entire field was strewed with our balloon baggage before we left the place. Some thousands of peasants came from great distances to see us, and we received them with open arms, distributing our provisions among them. We had taken with us a barrel containing sixty pints of wine; also twenty pints of brandy and the same quantity of coffee. The village policeman imbibed a goodly amount of these liquids, and in the evening became exceedingly friendly. His gait had become very unsteady, and having found our speaking-trumpet in the car, his great delight was to shout into it with all his force, thereby exciting roars of laughter among the bystanders. The inhabitants of Auneau, when they saw us descending from the skies, could scarcely believe their senses, and rubbed their eyes to make sure they were not dreaming. Whilst one of these good folks looked most obstinately through the telescope with the object-glass towards his eye, and would not believe that it was used to bring distant objects nearer, another persisted in calling our car a waggon, and expressed his conviction that it had come there by the railway.

In spite of all this joviality, some damage appeared to have been done to the crops, and our *garde-champêtre* at once took a note of it, and most comically serious he was in the performance of his duty. We had passed over twelve properties, and the entire damage was estimated at sixty-seven francs. Among those in the list of the sufferers, figured, for the sum of *one franc*, two children under age, and a *millionaire* who held out his hand for eighteen francs, in payment of purely problematical damages, for the rye would probably shoot up again in a few weeks. This was the largest item on the list.

At last it was decided that the town council of the place should take this matter in hand. We thought that the spectacle presented by the descent of a balloon the size of the *North Pole* was well worth sixty-seven francs—but the town council appeared to hesitate. The representatives of Auneau had drunk our wine; and they still deliberate on this important question—the paper that claims the amount has not yet been provided with a legal stamp!

It has been long thought that the larger a balloon, the greater the danger of the ascent. This is a singular prejudice. Our ascent in the *North Pole*, which was accomplished in a tolerably strong wind, gives it a firm denial. It is not necessary to be a very expert geometrician to understand that in a sphere the volume does

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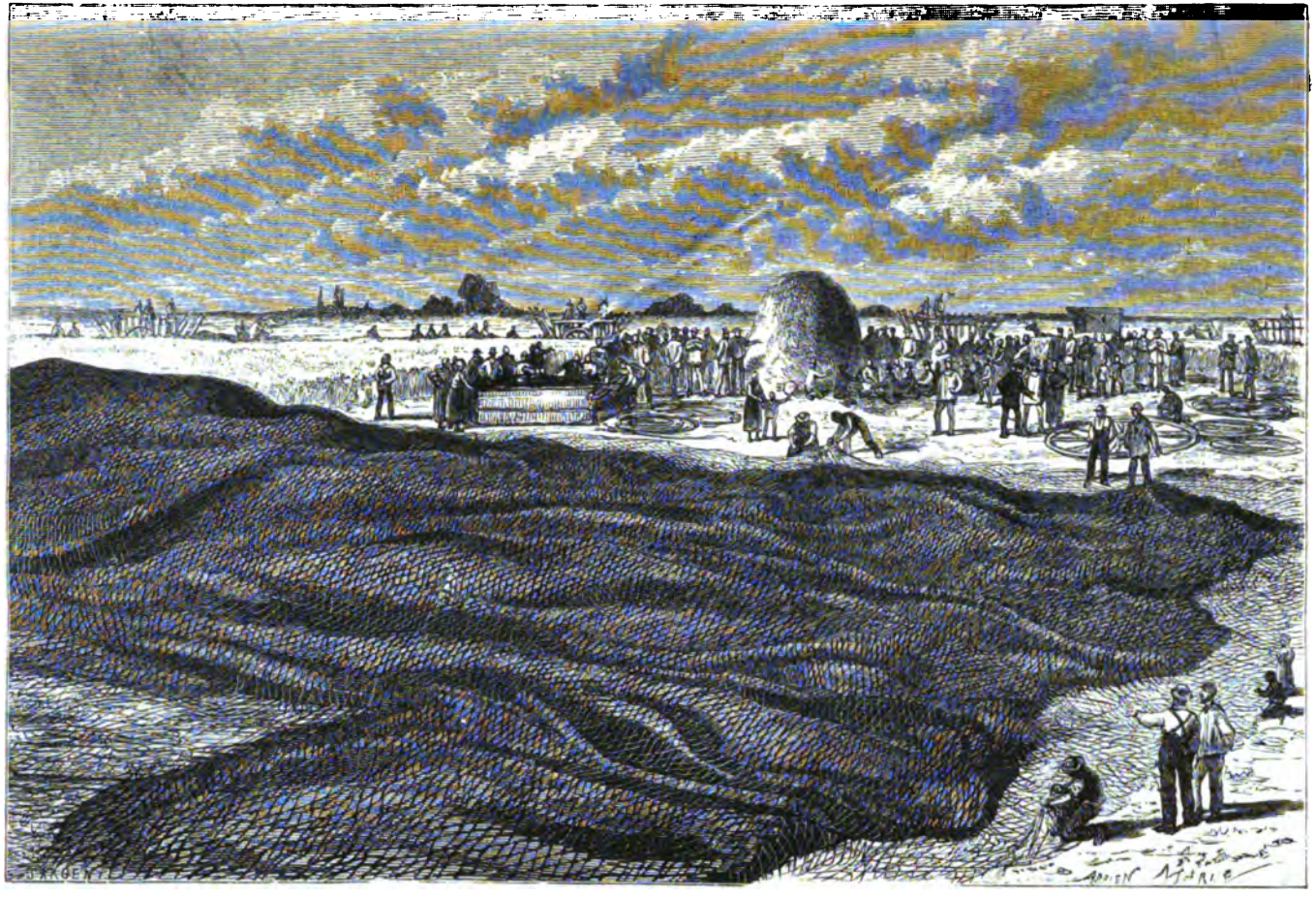

"THOUSANDS OF PEASANTS CAME FROM GREAT DISTANCES TO SEE US."

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UNIV. OF MICH.

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not increase at the same rate as the surface. When the diameter of the sphere is doubled, its volume becomes eight times greater, but its surface is only quadrupled. It is the battle of cubes against squares that demonstrates that the larger a balloon is the better it is. Nevertheless, there is a certain limit which the maker should not exceed. Moreover, the larger a balloon, the greater resistance its stuff can offer. Hence the envelope of the *North Pole* possesses considerable tenacity—much greater than could be given to an aërostat of smaller dimensions; and relatively to the ascensional power at our disposal, this envelope is lighter than that of a small balloon made of gold-beater's skin.

But all these advantages demand greater attention on the part of those who manage the balloon, for the consequences of error with a large balloon are much more serious than with a small one. For instance, if we allow the immense machine to take an improper amount of descent, it may be impossible to arrest its downward course in time. Thus it happens that aëronauts who are ignorant of physical principles are by no means fond of large balloons, for they have ever before their eyes the consequences of inevitable errors. These slaves of routine are much in the position of the master of a small fishing-smack to whom the management of the *Great Eastern* might be confided.

THE CAR OF THE "NORTH POLE."

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CONCLUSION.

(M. DE FONVIELLE AND G. TISSANDIER.)

IF the truthful pages we have written have received any attention from our readers, they will have gleaned from them that our atmospheric crusades have given us profound faith in the future of aërial navigation.

We do not mean to say that we have any system for guiding balloons to place prominently before the public, for we are fully persuaded that what has happened for railways, steamboats, or even ordinary ships, will likewise happen for balloons. The railway was discovered, in principle, the day that an English workman caused his coal-waggons to roll along wooden rails. The *Great Eastern* was virtually discovered the day that the first savage dared to risk himself upon a river with no other support than the hollowed stem of a tree.

Balloons are not yet far from this state of infancy. And how is this? Are unheard-of efforts of intellect necessary to improve them? or must we do so by having recourse to some new principle, such as that advocated by those who believe in the possibility of causing objects *heavier than air* to rise? Not at all. We do not deny that a more advanced state of mechanics will doubtless have its effects upon the problem; but we assert that our engineers have not yet brought the whole of their actual resources to bear upon the subject. To construct a balloon which shall be capable of being guided through the air, will require an enormous amount of patience and numerous experiments with new appliances.

It is needless to speak of the use of balloons in studying questions connected with the atmosphere, either for the purposes of astronomy or any other science, for no one appears to doubt that we have here a vast field of exploration opened out to us. The Paris Academy of Sciences has, in fact, a permanent commission sitting upon the subject of Balloons; but why should this commission remain so permanently inactive? Why does it not condense the results of recent events,

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spread the taste for observation among aëronauts in general, and describe instruments that might be of use to them?

Again, why should not captive balloons be more utilized for the purposes of science? In the eyes of ordinary people a captive balloon is merely an aërostat attached to a long rope; but those accustomed to meteorological researches know that we have here a very powerful aid to observation and research—in fact, a scientific observatory of the highest importance.

The greatest obstacle that balloons have to strive against is that widespread belief that they are good for nothing. It is this prejudice that has caused certain intellectual persons, devoted to the problem of aërial navigation, to turn their attention to the theory of the possibility of raising bodies *heavier than the air*. We do not wish to induce people to abandon any kind of research, for, whatever its object, something useful is almost sure to come of it; but we cannot help considering this theory as a dangerous diversion in the wrong direction. The journal called the *Aëronaute*, which defends it so strenuously, actually announced some time back that it would give no more accounts of balloon ascents, since they were all alike and taught us nothing new! Do not let us abandon balloons, however, before we have really ascertained what can be done by their means. What would be said of a sailor who, a hundred years ago, abandoned his sailing vessel because he had a faint notion of steamboats? Or what should we think of a man who, in former years, refused to get into a coach because he had conceived the idea of a railway?

The guidance of balloons has, moreover, nothing absolutely impossible about it. In our ascent which terminated in the Clichy Cemetery, when our car was floating in an atmosphere which was perfectly calm, we should probably have made some way by means of paddles. And in our windy excursion described in this volume, we doubt that any apparatus, whether heavier than the air or not, could possibly have resisted the violence of the aërial currents.

There is a system of aërial navigation which appears to us to rival all the others; it consists in making use of the natural currents of air which flow at various heights in the atmosphere, and into which we may rise or sink by a proper adjustment of ballast. The excursions made by Mr. Glaisher have shown the almost constant existence of these currents of air flowing in different directions at different elevations. And we have shown in our ascent from Calais, and in that of the *North Pole* balloon, that the use of these currents is by no means chimerical. These notions have since been again confirmed by a more recent ascent made by Messrs. Duruof

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and Bertaux at Monaco, and we have no doubt that new proofs will be forthcoming every year.

In fact, no one can define the limits of this method, which will be the more fertile in results the more our knowledge of the atmospheric currents extends; and the sooner we become acquainted with their directions and velocities the better.

Many readers will, no doubt, reproach us for not coming down from the air with our hands full of new discoveries, and thereby throwing out a new basis for the future of meteorological science. It might have been otherwise if we had had better balloons at our disposal, and if the ascents had been more numerous and more systematically organized. But in the aërial workshop it is not possible to do good work with bad tools.

Nevertheless, this book, we sincerely hope, will make an epoch in the history of aërostatics, for it is the first time that a series of aërial scenes have been published as observed by aëronauts. It is the first time that artists have gone up in balloons for the purpose of familiarizing the eyes of the public with the scenes they have been called upon to reproduce with the pencil. And if balloons, so much neglected in modern times, had merely placed before the gaze of the aërial explorer these incomparable panoramas, these magnificent scenes, before which the Alps themselves grow small, whilst earthly sunsets are eclipsed in splendour, and the ocean itself drowned in an ocean of light still more vast, would they not have done enough for the glory of Montgolfier and Pilâtre?

THE END.

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